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TWO SONNETS.

If we be fools of chance, indeed, and tend
  No whither, then the blinder fools in this:
  That, loving good, we live, in scorn of bliss,
Its wageless servants to the evil end.

If at the last, man's thirst for higher things
  Be quench'd in dust, the giver of his life,
  Why press with growing zeal a hopeless strife,—
Why—born for creeping—should he dream of wings?

O Mother Dust! thou hast one law so mild,
  We call it sacred—all thy creatures own it—
The tie which binds the parent and the child,—
  Why has man's loving heart alone outgrown it?

Why hast thou travail'd so to be denied,
So trampled by a would-be matricide?

II.

Ripe fruit of science—demonstrated fact—
  We grasp at thee in trembling expectation,
  We humbly wait on thee for explanation:
Words of the Universe, enshrin'd in act!

Words, pregnant words, but only parts of speech
  As yet, curt utterance such as children use,
  With meanings struggling through but to confuse,
And hinted signs which soar beyond our reach.

Work on in patience, children of the time
  Who lend your faultering modes to Nature's voice,—
Fulfil your present task; some prize sublime
  Ye wot not of your hearts may still rejoice,—

Some strain of music shape the wild turmoil,
And consecrate the pauses of your toil.

Spectator. EMILY PFEIFFER.

THE HAPPY MAN.

No longer any choice remains;
  All beauty now I view,
All bliss that womankind contains,
  Completely summ'd in you.

Your stature marks the proper height;
  Your hair the finest shade;
Complexion—Love himself aright
  Each varying tint hath laid.

No longer &c.

Your voice—the very tone and pitch
  Whereto my heart replies!
Blue eyes, or black, or hazel,—which
  Are best? *Your*-colour'd eyes.

No longer &c.

Your manners, gestures, being of you,
  Most easily excel.
Have you defects? I love them too,
  I love yourself so well.

No longer &c.

To me, once careworn, veering, vext,
  Kind fate my Queen hath sent;
In full allegiance, unperplext,
  I live in sweet content.

No longer any choice remains;
  All beauty now I view,
All bliss that womankind contains,
  Completely summ'd in you.

Fraser's Magazine.

THE SPECTRE OF THE ROSE.

FROM THE FRENCH OF THEOPHILE GAUTIER.

The original begins:
"Souleve ta paupière close,
  Qu'effleure un songe virginal!"

I.

Those slumbering lids unclose,
  Where pure dreams hover so light!
A spectre am I—the Rose
  That you wore at the ball last night.
You took me, watered so late
  My leaves yet glistened with dew;
And amid the starry fête
  You bore me the evening through.

II.

O lady, for whom I died,
  You cannot drive me away!
My spectre at your bed-side
  Shall dance till the dawning of day.
Yet fear not, nor make lament,
  Nor breathe sad psalms for my rest!
For my soul is this tender scent,
  And I come from the bowers of the Blest.

III.

How many for deaths so divine
  Would have given their lives away!
Was never such fate as mine—
  For in death on your neck I lay!
To my alabaster bier
  A poet came with a kiss:
And he wrote, "A rose lies here,
  But kings might envy its bliss."

FRANCIS DAVID MORICE.

Macmillan's Magazine.

From The British Quarterly Review.

THE DEPTHS OF THE SEA.*

THE results of the deep-sea explorations recently carried out by Dr. Carpenter, Mr. J. Gwyn Jeffreys, and Professor Wyville Thomson have excited so much interest, not only among men of science, but also among the general public — and this not less in other countries than in our own — that we feel sure of our readers' welcome to an endeavour to place before them a general account of the most important of them; chiefly directing their attention to those new *ideas* which these researches have introduced into science, since without such any mere accumulation of *facts* remains a *rudis indigestaque moles*, not animated and quickened by any vital force. On two of these ideas we shall especially dwell — viz., the doctrine advocated by Dr. Carpenter, of a General Oceanic Circulation sustained by thermal agency alone, characterized by Sir Roderick Murchison* as one, which, "if borne out by experiment," would "rank amongst the discoveries in physical geography, on a par with the discovery of the circulation of the blood in physiology;" and Professor Wyville Thomson's doctrine of the Continuity of the Chalk-formation on the bed of the Atlantic, from the Cretaceous epoch to the present time, of which Mr. Kingsley has spoken as a "splendid generalization, to have added which to the sum of human knowledge is a glorious distinction."

No stronger testimony could have been given to the opinion entertained by the most competent judges, as to the great value of the work already done, and the probability that a far richer harvest would be gathered by the prosecution of similar researches on a more extended scale, than the fact that our late Government, certainly not unduly liberal in its encouragement of Science, unhesitatingly adopted the proposal for a scientific circumnavigation expedition submitted to the Admiralty by Dr. Carpenter on the part of himself and his colleagues, fitted out the *Challenger* with every appliance asked for by the committee of the Royal Society to which the scientific direction of the expedition was entrusted, and sent her forth fully equipped for her work, under the command of one of the ablest surveying officers in the naval service, together with a complete civilian scientific staff, under the experienced direction of the distinguished naturalist by whom the inquiry was initiated, and who had taken an active share in the earlier prosecution of it.

Professor Wyville Thomson's beautifully illustrated volume, entitled "The Depths of the Sea," which made its appearance on the eve of the departure of the *Challenger* expedition, gives a highly interesting account of the explorations carried on by Dr. Carpenter and himself in the tentative *Lightning* cruise of 1868, and by the same gentlemen, with the co-operation of Mr. J. Gwyn Jeffreys, in the *Porcupine* exploration which extended over the four summer months of 1869. In the work of the following year, which extended into the Mediterranean, Professor Wyville Thomson was prevented by illness from participating, and its results are but slightly noticed in his volume. And of the results of Dr. Carpenter's second visit to the Mediterranean in 1871, no mention whatever is made, as they had not long been published when "The Depths of the Sea" made its appearance. They constitute, however, the subject of two very elabo-

* (1.) *The Depths of the Sea.* An account of the General Results of the Dredging Cruises of H.M.SS. *Porcupine* and *Lightning* during the Summers of 1868, 1869, and 1870, under the Scientific Direction of Dr. Carpenter, F.R.S., J. Gwyn Jeffreys, F.R.S., and Dr. Wyville Thomson. By C. WYVILLE THOMSON, LL.D., D.Sc., F.R.S.S.L. and E., F.L.S., F.G.S., &c., Regius Professor of Natural History in the University of Edinburgh, and Director of the Civilian Scientific Staff of the *Challenger* Exploring Expedition. With numerous Illustrations and Maps. London.

(2.) *Reports of Deep-Sea Explorations carried on in H.M.SS. Lightning, Porcupine, and Shearwater, in the years* 1868, 1869, 1870, *and* 1871. "Proceedings of the Royal Society," Nos. 107, 121, 125, and 138.

(3.) *H.M.S. Challenger: Reports of Captain G. S. Nares, R.N., with Abstracts of Soundings and Diagrams of Ocean Temperature in the North and South Atlantic Oceans.* Published by the Admiralty: 1873.

(4.) *Lecture on "The Temperature of the Atlantic," delivered at the Royal Institution on March 20th,* 1874. By WILLIAM B. CARPENTER, M.D., LL.D.

* "Proceedings of the Royal Geographical Society," January, 1871.

rate reports in the "Proceedings of the Royal Society," in which Dr. Carpenter fully develops his doctrine in regard to Oceanic Circulation, meets the objections which had been raised to it, and discusses the question of the Gulf Stream (necessarily mixed up with it) on the basis of the most recent information. And, as his views have received very striking confirmation from the observations made during the survey of the North and South Atlantic Oceans by the *Challenger*, of which the results have been recently published by the Admiralty as the first fruits of the circumnavigation expedition, we shall treat this portion of the subject in accordance with Dr. Carpenter's doctrine, rather than with that of Professor Wyville Thomson. The latter, while devoting a special chapter of his work to "The Gulf Stream," seems to have proceeded on a foregone conclusion in regard to the extent of its agency, which weakens the value of his argument; and hence, while cordially commending every other portion of Professor Wyville Thomson's book to the attention of our readers, we would ask them in perusing this chapter to suspend their judgment, until they have acquainted themselves with the arguments which may be advanced on the other side.

We propose, in the following sketch of the results of these inquiries, to dwell on the generalizations to which they point, rather than on any of the multitudinous details which they have added to our physical and biological knowledge. A very interesting selection of these has been made by Professor Wyville Thomson; and there is not one of his admirable figures and descriptions, which will not be deeply interesting to every one who is possessed of but an elementary knowledge of Zoology, as showing what manner of creatures they are which dwell in those depths which were previously deemed uninhabitable.

The state of our previous knowledge, or rather of our ignorance, in regard to the condition of the deep sea, is thus graphically described by Professor Wyville Thomson: —

> The sea covers nearly three-fourths of the surface of the earth, and until within the last few years very little was known with anything like certainty about its depths, whether in their physical or their biological relations. The popular notion was, that after arriving at a certain depth the conditions became so peculiar, so entirely different from those of any portion of the earth to which we have access, as to preclude any other idea than that of a waste of utter darkness, subjected to such stupendous pressure as to make life of any kind impossible, and to throw insuperable difficulties in the way of any attempt at investigation. Even men of science seemed to share this idea, for they gave little heed to the apparently well-authenticated instances of animals, comparatively high in the scale of life, having been brought up on sounding lines from great depths, and welcomed any suggestion of the animal having got entangled when swimming on the surface, or of carelessness on the part of the observers. And this was strange, for every other question in physical geography had been investigated by scientific men with consummate patience and energy. Every gap in the noble little army of martyrs striving to extend the boundaries of knowledge in the wilds of Australia, on the Zambesi, or towards the North or South Pole, was struggled for by earnest volunteers; and still the great ocean slumbering beneath the moon covered a region apparently as inaccessible to man as the Mare Serenitatis. (p. 2.)

Thanks, however, to the enterprise of the scientific men who commenced the inquiry, to the support which they received from the Royal Society, and to the efficient means placed at their disposal year after year by the Admiralty, it has been shown that with sufficient power and skill, an ocean of three miles' depth may be explored with as much certainty, if not with as much ease, as what may now be considered the shallows around our shores, lying within 100 fathoms of the surface.

> The bed of the deep sea, the 140,000,000 of square miles which we have now added to the legitimate field of natural history research, is not a barren waste. It is inhabited by a fauna more rich and varied on account of the enormous extent of the area; and with the organisms in many cases apparently even more elaborately and delicately formed, and more

exquisitely beautiful in their soft shades of colouring and in the rainbow tints of their wonderful phosphorescence, than the fauna of the well-known belt of shallow water teeming with innumerable invertebrate forms, which fringes the land. And the forms of these hitherto unknown living beings, and their mode of life, and their relations to other organisms, whether living or extinct, and the phenomena and laws of their geographical distribution, must be worked out. (p. 4.)

The first point to be determined in the exploration of what are often called the "fathomless abysses" of the ocean, is their actual *depth*. This, it might be supposed, would be very easily ascertained by letting down (as in ordinary "sounding") a heavy weight attached to a line strong enough to draw it up again, until the weight touches the bottom; the length of line carried out giving the measure of the depth. But this method is liable to very great error. Although a mass of lead or iron thrown freely into the sea would continue to descend at an increasing rate (at least until the augmented friction of its passage through the water should neutralize the accelerating force of gravity), the case is quite altered when this mass is attached to the end of a thick rope, of which the immersed length increases as the weight descends. For the friction of such a rope comes to be so great, when a mile or two has run out, as seriously to reduce the rate of descent of the weight, and at last almost to stop it; and since the upper part of the rope will continue to descend by its own gravity (which, when the rope has been wetted throughout, so as to hold no air between its fibres, considerably exceeds that of water), any quantity of it may be drawn down, without the bottom being reached by the weight at its extremity. Further, if there should be a movement, however slow, of any stratum of the water through which it passes, this movement, acting continuously against the extended surface presented by the rope, will carry it out horizontally into a loop or "bight," the length of which will depend upon the rate of the flow and the time during which the line is being acted on by it. Under such circumstances it is impossible that the impact of the weight upon the bottom, even if it really strikes the ground, should be perceptible above; and thus the quantity of rope which runs out, may afford no indication of the actual depth of the sea-bed. Hence all those older "soundings" which were supposed to justify the statement that the bottom of the ocean lies in some places at not less than six or eight miles depth, — still more, those which represented it as absolutely unfathomable, — are utterly untrustworthy.

Various methods have been devised for obtaining more correct measurements, of several of which illustrated descriptions will be found in Professor Wyville Thomson's pages. One principle may be said to be common to them all; namely, that regard should be had, not so much to the recovery of the plummet or "sinker," as to securing the vertical direction of the line to which it is attached, so that the measurement of the amount run out may give as nearly as possible the actual depth of water through which the sinkers have descended. Now, as it is by the friction of the line through the water that the rate of descent of the plummet is increasingly retarded, it is obvious that the size of the line should be reduced to a minimum; but since, for the purposes of scientific exploration, it is requisite to send down and bring up again thermometers and water-bottles, as well as to obtain samples of the bottom, it is now found desirable to employ, not the fine twine or silk thread of the earlier instruments constructed on this plan, but a line about the thickness of a quill, which, if made of the best hemp, will bear a strain of more than half a ton. The plummet being disengaged by a simple mechanical contrivance, and being left on the sea-bed, the instruments only are drawn up by the line.

The trustworthiness of the modern method of sounding is shown by the coincidence of the results obtained by different marine surveyors. Thus the *Porcupine* soundings taken about 200 miles to the west of Ushant, which reached to a depth of 2,435 fathoms, correspond very closely with the soundings previously taken in the same locality for the French

Atlantic cable; and the soundings taken by the *Porcupine* and the *Shearwater* in the Strait of Gibraltar, bear an equally exact correspondence with those previously laid down in the Admiralty charts, on the authority partly of our own and partly of French surveyors; though the deeper and narrower part of this Strait, in which the current runs the strongest, had been formerly pronounced "unfathomable." Hence it may be said that the ocean depths, on areas that have been carefully examined, are known with almost the same exactness as the heights of mountain ranges. Until very recently there was reason to believe that the depth of the North Atlantic nowhere exceeds about 2,800 fathoms (16,800 feet); but the *Challenger* has recently met with the extraordinary depth of 3,800 fathoms (more than four miles), a little to the north of St. Thomas's; and that this result did not proceed from an accidental error, is shown by the fact that two thermometers, protected in the manner to be hereafter described, which had been tested under a hydrostatic pressure of three tons and a half (corresponding to a column of 2,800 fathoms) were crushed by the excess.

Before proceeding to inquire into the relation which the depth of the ocean bears to its temperature, and to the distribution of animal life on the sea-bed, we may stop to point out how important is a knowledge of the exact depth of the sea-bottom to the geologist. It is only by such knowledge that he can judge what departures from the present distribution of land and sea would have been produced by those changes of level, of which he has evidence in the upheaval and submergence of the stratified deposits that formed the ocean-bed of successive geological periods; or that he can obtain the clue to the distribution of the animal and vegetable forms, by which he finds those periods to have been respectively characterized. For example, a knowledge of the comparative shallowness of the Seas that surround the British Islands, enables us readily to understand the former connection of our islands, not merely with each other, but with the Continent of Europe. For they stand upon a sort of platform, of which the depth is nowhere greater than 100 fathoms; so that an elevation of 600 feet (only half as much again as the height of St. Paul's) would not only unite Ireland to Great Britain, and extend the northern boundary of Scotland so as to include the Orkney and Shetland Islands, but would obliterate a large part of the North Sea, which (with the exception of a narrow channel along the coast of Norway and Sweden) would become a continuous plain, connecting our present eastern coast with Denmark, Holland, and Belgium; would in like manner wipe out the British Channel, and unite our southern coast with the present northern shores of France; and would carry the coast-line of Ireland a long distance to the west and south-west, so as to add a large area of what is now sea-bottom to its land-surface. Even an elevation not greater than the height of St. Paul's would establish a free land communication between England and the Continent, as well as between England and Ireland. And thus we see how trifling a change of level, by comparison, would have sufficed to produce those successive interruptions and restorations of continuity, of which we have evidence in the immigrations of the Continental mammalia, on each emergence that followed those successive submergences of which we have evidence in our series of Tertiary deposits.*

Many of our readers, we doubt not, have been in the habit — as we formerly were ourselves — of looking at the Mediterranean as only a sort of British Channel on a larger scale; whereas it is a basin of quite another character. For whilst the separation between Great Britain and the Continent may be pretty certainly attributed to the removal, by denudation, of portions of stratified deposits that were originally continuous, the extraordinary depth of the Mediterranean basin can scarcely be accounted for on any other hypothesis than that of the subsidence of its bottom; which was, perhaps, a part of that "crumpling" of the earth's crust, which occasioned the elevation of the high mountain chains in its neighbourhood. This great inland sea may be said to consist of two basins; the western extending from the Strait of Gibraltar to the "Adventure" and "Skerki" banks, which lie between Sicily and the Tunisian shore; while the eastern extends from the Adventure bank to the coast of Syria. Now, over a large part of the former area, the depth ranges to between 1,000 and 1,500 fathoms, being often several hundred fathoms within sight of land; and over a large part of the latter, it ranges from

* See Professor Ramsay's "Physical Geology and Geography of Great Britain," chap. xii.

1,500 to 2,000 fathoms, the descent being so rapid that a depth of upwards of 2,000 fathoms (above 12,000 feet) is met with at not more than fifty miles to the east of Malta. But the ridge between Capes Spartel and Trafalgar, which constitutes the "marine watershed" between the Mediterranean and the Atlantic basins, is nowhere more than 200 fathoms in depth; and as the Adventure and Skerki banks, which lie between Sicily and the Tunisian coast, are within that depth (some of their ridges being not more than fifty fathoms from the surface), it is obvious that an elevation of 1,200 feet, by closing the Strait of Gibraltar, and uniting Sicily with Africa, would convert the Mediterranean into two great salt-water lakes, still of enormous depth, and of but slightly reduced area,—as is shown in regard to the Western basin, in Plate v. of "The Depths of the Sea." That such a partition did at one time exist, is evident from the number and variety of the remains of large African mammalia entombed in the caves of Sicily and in the Tertiary deposits of Malta. Thus in caverns of the hippurite limestone, not far from Palermo, there is a vast collection of bones of the hippopotamus, associated with those not only of *Elephas antiquus*, but of the living African elephant. And in Malta there have been found remains of several species of elephants; amongst them a *pigmy* of about the size of a small ass. It is not a little curious that there is distinct evidence of considerable local changes of level, in various parts of the Mediterranean area, within the human period. Thus Captain Spratt has shown that the Island of Crete has been raised about twenty-five feet at its western extremity, so that ancient ports are now high and dry above the sea; while at its eastern end it has sunk so much, that the ruins of old towns are seen under water. And on the southern coast of Sardinia, near Cagliari, there is an old sea-bed at the height of nearly 300 feet above the present level of the Mediterranean, which contains not merely a great accumulation of marine shells, but numerous fragments of antique pottery—among them a flattened ball with a hole through its axis, which seems to have been used for weighting a fishing-net.

It is doubtful, however, whether the western basin of the Mediterranean was ever cut off from the Atlantic; for though there is pretty clear evidence of former continuity between the two "Pillars of Hercules," the evidence is equally clear of a depression of the south-western portion of France at no remote geological period; so that a wide communication would have existed between the Bay of Biscay and the Gulf of Lyons, along the course of the present canal of Languedoc. And certain very curious conformities between the marine fauna of the Mediterranean and that of the Arctic province, are considered by Mr. Gwyn Jeffreys as indicating that Arctic species which migrated southwards in the cold depths congenial to them, found their way into the Mediterranean through this channel. We shall presently see what very important modifications in the condition of this great Inland Sea, affecting its power of sustaining animal life, would result from any considerable increase in the depth of its channel of communication with the great oceanic basin, from which all but its superficial stratum is now cut off.

Another most interesting example of the importance of the information supplied by exact knowledge of the depth of the sea, is furnished by the inquiries of Mr. A. R. Wallace in regard to the geographical distribution of the fauna of the Eastern Archipelago. For while Java, Sumatra, and Borneo clearly belong to the Indian province, Celebez, the Moluccas, and New Guinea no less clearly belong to the Australian; the boundary-line between them passing through the Strait of Lombok—a channel which, though no more than fifteen miles in width, separates faunæ not less differing from each other than those of the Old and the New Worlds. The explanation of these facts becomes obvious, when we know that an elevation of no more than fifty fathoms would unite Borneo, Sumatra, and Java with each other, and with the peninsula of Malacca and Siam; while an elevation of 100 fathoms (600 feet) would convert nearly the whole of the bed of the Yellow Sea into dry land, and would reunite the Philippine Islands to the south-eastern part of the continent of Asia. But even the latter elevation would not connect the upraised area with the Australian province, the depth of the narrow dividing strait being greater than that of any part of the large Asiatic area now submerged. In some parts of the Australian portion of the Eastern Archipelago, indeed, there are some very extraordinary and sudden depressions, showing the activity of the changes which have taken place in the

crust of this portion of the earth within a very recent geological period. Thus, whilst every geologist knows that the Himalayas are not only the highest, but among the newest of great mountain ranges — even the later Tertiary deposits lying in slopes high up on their flanks — it is not a little curious to find the almost land-locked Celebez Sea going down to the enormous depth of 2,800 fathoms, or three miles. That this remarkable depression is in some way connected with the volcanic activity of the region, may be surmised from the fact that the similar hollow, *nearly a thousand fathoms deeper*, lately found by the *Challenger* a little to the north of St. Thomas's (p. 6), lies at what may be regarded as the northern termination of that "line of fire," which has elevated the chain of islands that separate the Caribbean Sea from the Atlantic Ocean.

In the general uniformity of depth of the present area of the North Atlantic, however, and in the conformation of its boundaries on either side, we have evidence that this vast basin was a deep sea at least as far back as the Cretaceous epoch. From the edge of the 100-fathom platform on which the British Isles are based, and which extends about fifty miles to the westward of the coast of France, between Brest and Bayonne, the bottom rapidly descends to 1,500 fathoms, and generally to more than 2,000; so that, with the exception of the modern volcanic plateau of the Azores, the sea-bed of the North Atlantic undulates gently from the European to the American coast, at an average depth of at least 2,000 fathoms, or 12,000 feet.* Now, as Professor Wyville Thomson remarks, all the principal axes of elevation in the North of Europe and in North America have a date long anterior to the deposition of the Tertiary, or even of the newer Secondary strata; though some of them, such as those of the Alps and Pyrenees, have received great accessions to their height in later times. All these newer beds have, therefore, been deposited with a distinct relation of position to certain important features of contour, which, dating back to more remote periods, are maintained to the present day: —

Many oscillations have doubtless taken place, and every spot on the European plateau may have probably alternated many times between sea and land; but it is difficult to show that these oscillations have occurred in the North of Europe to a greater extent than from 4,000 to 5,000 feet, the extreme vertical distance between the base of the Tertiaries and the highest point at which Tertiary or Post-tertiary shells are found on the slopes and ridges of mountains. A subsidence of even 1,000 feet would, however, be sufficient to produce over most of the northern land a sea 100 fathoms deep — deeper than the German Ocean; while an elevation of a like amount would connect the British Isles with Denmark, Holland, and France, leaving only a long deep fjord separating a British peninsula from Scandinavia. (p. 473.)

There is abundant evidence that these minor oscillations, with a maximum range of 4,000 or 5,000 feet, have occurred over and over again all over the world within comparatively recent periods, alternately uniting lands, and separating them by shallow seas, *the position of the deep waters remaining the same.* And though mountain-ridges have been elevated from time to time, to heights equalling or exceeding the average depth of the Atlantic, there is no reason whatever to believe that any area at all comparable to that of the North Atlantic has ever changed its level to the extent of 10,000 feet. As Sir Charles Lyell has remarked ("Principles of Geology," 1872, p. 269): —

The effect of vertical movements equally 1,000 feet in both directions, upwards and downwards, is to cause a vast transposition of land and sea in those areas which are now continental, and adjoining to which there is much sea not exceeding 1,000 feet in depth. But movements of equal amount would have no tendency to produce a sensible alteration in the Atlantic and Pacific Oceans, or to cause the oceanic and continental areas to change places. Depressions of 1,000 feet would submerge large areas of existing land; but *fifteen times as much movement* would be required to convert such land into an ocean of average depth, or to cause an ocean three miles deep to replace any one of the existing continents.

Thus, then, whilst the wide extent of Tertiary strata in Europe and the North of Africa sufficiently proves that much dry land has been gained in Tertiary and Post-tertiary times along the European

* The Bermuda group has been shown by the *Challenger* soundings to rise like a vast column from a small base lying at a depth of more than three miles; and since there is no submarine ridge of which it could be supposed to be an outlier, and the islands are themselves entirely composed of coral, it seems likely that we have here a typical exemplification of Mr. Darwin's remarkable doctrine, that though the reef-building coral animals cannot live and grow at a greater depth than twenty fathoms, yet that by the slow progressive subsidence of the bottom, and the contemporaneous addition of new coral to the summit, a pile of coral limestone may be built up (or rather may grow up) to any height.

border of the Atlantic, while the great mountain-masses of Southern Europe give evidence of much local disturbance, it is extremely improbable that any such contemporaneous depression could have taken place, as would have sufficed to produce the vast basin of the Atlantic. For as Professor Wyville Thomson justly remarks: —

> Although the Alps and the Pyrenees are of sufficient magnitude to make a deep impression upon the senses of men, taking them together, these mountains would, if spread out, only cover the surface of the North Atlantic to the depth of six feet; and it would take at least 2,000 times as much to fill up its bed. It would seem by no means improbable that while the edges of what we call the great Atlantic depression have been gradually raised, the central portion may have acquired an equivalent increase in depth; but it seems most unlikely that while the main features of the contour of the northern hemisphere remain the same, an area of so vast an extent should have been depressed by more than the height of Mont Blanc. (p. 477.)

We quite agree with him, therefore, in the belief that a considerable portion of this area must have been constantly under water during the whole of the Tertiary period; and looking to the relation of this area to that of the old Cretaceous sea which formerly occupied the place of a large part of what is now the continent of Europe, we feel justified in concurring with Mr. Prestwich * in the conclusion that this sea extended continuously from Asia to America. It may well have been that when the European portion of that sea-bottom underwent elevation into the chalk cliffs of Dover, a corresponding subsidence took place in the Atlantic area. But this subsidence would have only added a little to the depth of what must have previously been an enormously deep basin, without altering its condition in any essential degree; and thus on *physical* grounds alone, we seem justified in concluding that an essential continuity must have existed in the deposits progressively formed on this sea-bottom, from the Cretaceous epoch to the present time. How strikingly this conclusion harmonizes with the results obtained by the *biological* exploration of the "Depths of the Sea," will be shown hereafter.

The *pressure* exerted by the waters of the ocean, either upon its bed, or upon anything resting upon it, may be readily calculated from its depth; for the weight of a column of one inch square is almost exactly a ton for every 800 fathoms of its height; and consequently the pressure at 2,400 fathoms depth is *three tons upon every square inch*, while at 3,800 fathoms it is *nearly five tons*. How life can be sustained under this enormous pressure, is a question to be considered hereafter; at present we shall speak only of its effects on the instruments employed to determine the *temperature* of the deep sea, —a part of the inquiry which is second to none in interest and importance. For while it is from accurate observations of the temperature of the ocean-bottom, that we derive our knowledge of those differences of submarine climate, on which the distribution of animal life mainly depends, it is from observations of the temperature of successive strata that we derive our chief information as to that great system of *oceanic circulation*, which, altogether independent of those superficial currents that have their origin in winds, has a most powerful influence upon terrestrial climate,—modifying alike the extremes of equatorial heat and of polar cold,—and also, by bringing every drop of ocean-water at some time or other to the surface, gives to it the power of sustaining animal life on its return to the sea-bed over which it flows, at depths it may be, of thousands of fathoms.

It was in consequence of the remarkable character of the temperature-observations made in the Channel between the North of Scotland and the Faroe Islands, in the tentative *Lightning* cruise of 1868, that the importance of obtaining thoroughly trustworthy observations of ocean-temperature was first brought prominently into notice. At that time the doctrine of a uniform deep-sea temperature of 39° was generally accepted among physical geographers, chiefly on the basis of the temperature-observations made in Sir John Ross's Antarctic Expedition; which were considered by Sir John Herschel as justifying the assumption that the temperature of the sea *rises* with increase of depth in the two Polar areas, while it *sinks* with increase of depth in the Equatorial zone,—there being an intermediate line of division between these regions, corresponding with the annual isotherm of 39°, on which the temperature of the sea is uniform from the surface to the bottom. It is true that lower bottom-temperatures than 39° had been occasionally observed, even in

* Presidential Address to the Geological Society, 1871.

the intertropical zone; but these were considered as proceeding from special "Polar currents." Thus the United States coast surveyors had met with a temperature of 35° in the very channel of the Gulf Stream, the surface temperature of which was 80°; and Captain Maury regarded this as a cold current coming down from the north beneath the Gulf Stream, to replace the warm water which is carried by that great surface-current to moderate the cold of Spitzbergen. And Captain Shortland, of H.M.S. *Hydra*, who had surveyed the line between Aden and Bombay, along which a telegraph cable has since been carried, found a temperature of 36 1-2°, at depths of from 1,800 to 2,000 fathoms in the bed of the Arabian Gulf, at about 12° north of the equator.

Now the *Lightning* temperature-soundings, carried on in different parts of the above-mentioned channel, which has an average depth of between 500 and 600 fathoms, showed a difference of from 13° to 15°, at depths almost identical, between points which were sometimes not many miles apart; the bottom temperature, which, according to Sir John Herschel's doctrine, ought to have been everywhere 39°, being as high as 45° on some spots, and as low as 32° on others. With this marked difference of temperature, there was an equally well-marked difference alike in the mineral characters of the two bottoms, and in the types of animal life they respectively yielded. For whilst the "warm area," as Dr. Carpenter named it, was covered by the whitish globigerina-mud, which may be considered as chalk in process of formation, and supported an abundant and varied fauna, of which the *facies* was that of a more southerly clime, the "cold area" was entirely destitute of globigerina-mud, and was covered with gravel and sand containing volcanic detritus, on which lay a fauna by no means scanty, but of a most characteristically boreal type.

Here, then, whatever might be the error in the determination of the *actual* temperatures, occasioned by the pressure of about three-fourths of a ton per square inch on the bulbs of the thermometers employed, it became obvious that there could be no such error in regard to the striking *differences* which showed themselves between temperature-observations taken at similar depths; and the importance of this phenomenon became so apparent to all who were interested in the inquiry, that as soon as the further prosecution of these researches had been decided on, arrangements were made for testing the effect of pressure upon the thermometers used for deep-sea observations, which are maximum and minimum self-registering instruments of the ordinary (Six's) construction, made with special care to prevent the displacement of the indices by accidental jerks. These instruments being placed under water-pressure in the interior of a hydrostatic press, the very best of them were found to rise 8°, or even 10°, when the pressure-gauge indicated three and a quarter tons on the square inch; whilst inferior instruments rose 20°, 30°, 40°, or even 50° under the same pressure. Thus it became obvious that no reliance could be placed on most of the older temperature-observations taken at great depths; those only being at all to be trusted, which had been taken with instruments whose probable error could be ascertained. Thus the temperature-soundings taken not long previously, in various parts of the North Atlantic, by Commander Chimmo, R.N., and Lieutenant Johnson, R.N., gave 44° at depths exceeding 2,000 fathoms; but these, when corrected by an allowance of 8° for the known influence of pressure on thermometers of the Admiralty pattern, would give an *actual* temperature of 36°; and this agrees very closely with the results of the soundings recently taken by the *Challenger* with trustworthy instruments.

The existence of this most important error having been thus determined, the next question was how to get rid of it; and a very simple plan was devised by the late Professor W. A. Miller, which, carried into practice by Mr. Casella, was found to answer perfectly. It is due to Mr. Negretti, however, to state that this plan had been previously devised and adopted by him; and that he had supplied his "protected" thermometers to Captain Shortland, by whom they were used in the observations mentioned in the preceding pages, which, therefore, may be regarded as not far from the truth. The "protection" consists in the enclosure of the ordinary bulb of the thermometer by an outer bulb sealed round its neck; the space left between the two being partly filled with spirit or mercury, for the transmission of heat or cold between the medium surrounding the outer bulb and the liquid occupying the inner, but a vacuity being left, which

serves to take off pressure entirely from the inner bulb. It is obvious that if the whole intermediate space were occupied by liquid, any diminution of the capacity of the outer bulb would equally compress the inner; but that the vacuity acts as a sort of buffer-spring, entirely taking off pressure from the inner bulb,—the only effect of a reduction of the capacity of the outer bulb, by external pressure, being to diminish the unfilled part of the intermediate space.

All the temperature-observations since made under authority of the British Admiralty have been taken with these "protected" thermometers; which were first used in the *Porcupine* expeditions of 1869 and 1870, with the most satisfactory results. Every instrument sent out by the maker is tested to a pressure exceeding three tons, and is rejected if it shows more than the slight elevation of something less than a degree, which is attributable to the increase of the temperature of the water of the interior of the press, occasioned by its rapid compression. And the *Challenger* is furnished with a press of similar power, by which the thermometers in use may be tested from time to time, so as to make sure that they have undergone no deterioration. Two thermometers are used in every observation; and their ordinarily close accordance serves to give to their indications a high degree of trustworthiness; whilst, when they disagree, there is generally but little difficulty in determining, by collateral evidence, which of the two is likely to be wrong. Before proceeding to give a general summary of the temperature-observations carried out in the *Porcupine* expeditions of 1869 and 1870, with those collected in the North and South Atlantic during the first year of the *Challenger's* work — the results of which, so far as regards this subject, are now before us — we shall correct a prevalent misconception as to the temperature at which sea-water attains its maximum density.

Every one knows that fresh water *contracts* (and thus increases in density) as it cools from any higher temperature down to about 39°·2 Fahr.; and that it then *expands* again (thereby undergoing a diminution of density) as its temperature is reduced to 32° Fahr.; so that, when just about to freeze, it has the same density that it had at the temperature of about 46 1-2°. And thus it happens that before a pond or a lake is frozen, the surface-layers, whose temperature has been reduced by atmospheric cold, successively sink, and are replaced by warmer layers rising up from below, until the temperature of the deeper layers has been reduced to 39°·2; but that, when this stage has been reached, the further chilling of the surface-layer makes it lighter instead of heavier, so that it continues to float upon the warmer water beneath, which retains its temperature of 39°·2 though covered with a layer of ice or of ice-cold water. This, however, is not the case with sea-water, which, as was long ago ascertained by Despretz, differs from fresh water in continuing to contract (thus *augmenting* in density) down to its freezing point at about 27° Fahr.; and thus, when its surface is exposed to extreme atmospheric cold, each layer as it is chilled will descend, and will be replaced by a warmer layer either from beneath or from around; the coldest water always gravitating to the bottom, unless the effect of temperature be modified by some difference in salinity, or by movement of one stratum independently of another. Of the former conditon we have an example in the fact that, in the neighbourhood of melting ice, the water of which is either fresh (as in the case of icebergs, which are land glaciers that have floated out to sea), or of low salinity (as in the case of field-ice), the surface-layer is often colder than the more saline water beneath, on which it floats in virtue of its lower salinity. And the latter case constantly presents itself when some movement of translation slants upwards a deeper and colder stratum; which we shall presently find to be a general fact along the *eastern* coasts of our continents and to be attributable to the earth's rotation on its axis.

Under ordinary circumstances, then, the *minimum* temperature recorded by self-registering thermometers sent down with the sounding apparatus, may be expected to be the *bottom*-temperature; and this expectation has been fully verified by the results of the *serial* temperature-observations made in the *Porcupine* and *Challenger* expeditions; which have shown that the temperature of the Atlantic undergoes a progressive reduction from above downwards, but at a rate by no means uniform; and have clearly proved the fallacy of those older observations in which the temperature seemed to *rise* in the deepest stratum — the elevation of the "unprotected" thermometers having been really due to increase of pressure, not to increment of heat.

In order to render the scientific *rationale* of these observations more intelligible, we shall first state the results of the temperature-soundings taken by Dr. Carpenter in his two visits (1870 and 1871) to the Mediterranean, the peculiar conditions of whose basin have been already adverted to (p. 775).

We have here a great inland sea, of which the depth ranges downwards almost to that of the North Atlantic, and exceeds that of many other large oceanic areas; whilst its channel of communication with the great Atlantic basin is so shallow on the line of the "ridge," or "marine watershed" (as Dr. Carpenter terms it), between Capes Spartel and Trafalgar, that all but the most superficial strata of the two basins are completely cut off from each other. Both the summer and the winter surface-temperatures are very nearly the same in the two seas, with a slight excess on the side of the Mediterranean, which shows that its warmth is not dependent — as some of the extravagant advocates of the heating power of the Gulf Stream have supposed — on an influx of water from that source. And the rapid reduction of temperature which shows itself in the summer from the surface downwards, alike in the Mediterranean and in the Atlantic under the same parallels, clearly proceeds from the *superheating* of the superficial stratum under the influence of direct solar radiation. The surface-temperature of the Mediterranean during the months of August and September ranges between 76° and 80°; but the thermometer descends rapidly in the first fifty fathoms, the temperature at that depth being about 58°; and a slight further decrease shows itself between fifty and a hundred fathoms, at which depth the temperature is 54° near the western extremity of the basin, 55° nearer its middle, and 56° in its eastern part. Now from the hundred fathoms' plane to the bottom, even where it lies at a depth of 2,000 fathoms, *the temperature of the Mediterranean is uniform*, the difference never exceeding a degree. In the winter months, on the other hand, a temperature, alike of the surface, and of the superficial 100 fathoms' stratum, is brought down, by the reduction of the temperature of the superjacent atmosphere, to that of the uniform stratum beneath; so that *the entire column* of Mediterranean water has then a like uniform temperature from its surface to its greatest depths.

Now, we hold these observations to be of fundamental importance in two ways. For, in the first place, they show us the limit of the direct heating power of the solar rays that fall on the surface of the sea. There are few parts of the open ocean of which the surface-temperature is ever much higher than that of the Mediterranean; the most notable excess being seen in the Red Sea, the enclosure of which between two coast lines, nowhere more than 100 miles apart, while a large portion of it lies within the hottest land-area we know, causes its surface-temperature occasionally to rise even above 90°. The direct heating power of the solar rays at Aden, as measured by a thermometer with a blackened bulb, exposed on a blackened board, has been seen (in the experience of Colonel Playfair, our former consul at that station) to be above 212°; but that heat is mainly used up in converting the surface-film of the sea into vapour. All experiment shows that solar heat directly penetrates to so small a depth, and that the conducting power of water is so very slight, that some other means must exist for the extension of its influence even to the depth of twenty or thirty fathoms. This extension is attributed by Dr. Carpenter (who is supported in this and other physical doctrines by the most eminent authorities in that department of science) to a downward *convection*, taking place in the following mode: — Each surface-film, as it loses part of its water by evaporation, becomes more saline, and, therefore, specifically heavier, notwithstanding the increase of its temperature; and will thus sink, carrying down an excess of heat, until it loses its excess of salt by diffusion. It is, of course, replaced by a fresh film from below; and this will sink in its turn, to be again replaced by a less saline stratum; and the process will go on so long as the superheating action continues. Now, in the Mediterranean the depth of this "superheating" is limited by the periodical alternation of the seasons; but it might be expected that under the Equator, where even the winter temperature of the ocean-surface does not fall much below 80° (save under the local influence of cold currents), it would extend further downwards. The *Challenger* observations, however, have shown that this is not the case, the thickness of the superheated stratum being no greater under the Equator than it is anywhere else — a fact of which the significance will presently become apparent.

These Mediterranean observations, when taken in connection with others

made elsewhere on the constant temperature of deep lakes, show, in the second place, that the temperature of any enclosed body of water which is sufficiently deep to be but little influenced either by direct solar radiation, or by admixture of water flowing into it from without, will be the *isocheimal*, or lowest mean winter temperature, of the locality. We notice that in Dr. Carpenter's report of his first Mediterranean cruise, he connected it with the temperature of the solid crust of the earth, which there is reason to fix at between 50° and 54° in Central and Southern Europe; this being the constant temperature shown in deep caves, and at depths in the soil at which seasonal variations cease to show themselves, while there is as yet no such increment of mean temperature as shows itself at greater depths. But the observations taken during his second Mediterranean cruise, having proved that the temperature of the uniform substratum is higher in the eastern basin than in the western, in accordance with the higher isocheimal of the former, whilst those subsequently taken by Captain Nares, in the Gulf of Suez, gave a bottom-temperature of 71° at 400 fathoms, even in February, Dr. Carpenter has been led to abandon his first impression, and to regard the constant uniform temperature as determined by the isocheimal. And this conclusion, we have reason to believe, will be found to accord well with the results of observations made elsewhere. Thus it has been ascertained by Mr. Buchan, the able Secretary of the Scottish Meteorological Society, that in the deeper parts of Loch Lomond there is a permanent temperature of about 41°, and that this is exactly the mean of the temperature of the air during the winter months in that locality.

Hence, if it were possible for a body of ocean-water to remain unaffected by any other thermal agencies than those to which it is itself subjected, it seems clear that all below that superficial stratum of which the temperature varies with the season, would have a constant uniform temperature corresponding to the isocheimal of the locality. For whilst *cold* readily extends *downwards*, just as *heat* extends *upwards*, by convection, the extension of *heat* in a *downward* direction is very limited; the power of the sun being mainly expended in surface-evaporation.

As a corollary from the foregoing, it follows that when any stratum of ocean-water has a temperature *below* the isocheimal of the locality, it may be presumed to have flowed thither from a *colder* region; whilst, if the temperature of any stratum beneath 100 fathoms be *above* the isocheimal, it may be presumed to have flowed thither from a *warmer* region. This is simply to put upon differences of ocean-temperature the interpretation we constantly give to variations in the temperature of the atmosphere; which every one knows to be mainly dependent upon the direction in which the wind is moving. The comparative permanence of the great movements of the ocean is simply due to that of the antagonistic forces constantly operating to produce them.

A sort of epitome of the general oceanic circulation is presented, as Dr. Carpenter has pointed out, in that deep channel between the North of Scotland and the Faroe Islands, which was first explored by Professor Wyville Thomson and himself in the *Lightning* (p. 777), and which was next year examined more particularly by *serial* temperature-soundings taken with "protected" thermometers at every fifty fathoms' depth. In the north-eastern part of this channel, there was found to be a distinct horizontal division of its water into two strata; the *upper* one *warmer* than the normal, and the *deeper* one far *colder* than the normal, with a "stratum of intermixture" between the two. The deeper stratum, whose thickness is nearly *two thousand feet*, has a temperature ranging downwards from 32° to 29°; and it obviously constitutes a vast body of glacial water moving slowly from the Polar Sea to the south-west, to discharge itself into the North Atlantic basin. Traced onwards in this direction, it was found to be diverted by a bank rising in the middle of the channel, so as to be narrowed and at the same time increased in velocity; as was indicated by the rounding of the pebbles which covered the bottom, and also by the nearer approach of the cold stratum to the surface, consequent upon the shallowing of the bottom off the edge of the Faroe Banks. The other part of the channel was there occupied to its bottom by the warm flow slowly setting from the Mid-Atlantic to the north-east; and thus was formed that division of the bottom at the same depths into "cold" and "warm areas," which was noticed in the *Lightning* cruise (p. 778), and which was found to exert so important an influence on the distribution of animal life; whilst, when difference of

depth also came in as an element, a difference of bottom-temperature amounting to *fifteen degrees* sometimes showed itself within a distance of *three or four miles*.

On applying the same test to the deep temperature-soundings taken in the *Porcupine*, off the western coast of Portugal, in the same parallel as the middle of the western basin of the Mediterranean, we find that they plainly indicate the derivation of a large part of the deeper water of the Atlantic basin from a Polar source. For while the temperature of its superficial stratum varies with the season, being rather below that of the Mediterranean in the summer, and about the same in winter, there is beneath this a stratum of several hundred fathoms, which shows so slow a reduction down to about 700 fathoms, that the thermometer only falls to 49°. But between 700 and 900 fathoms there is a distinct "stratum of intermixture," comparable to that encountered in the "Lightning Channel," in which the thermometer falls *nine or ten degrees;* and beneath this is a vast body of water, ranging downwards from 900 fathoms to 2,000 or more, of which the temperature shows a progressive reduction to 36° or 35°·5.

There is here no distinct evidence of the presence of water *warmer* than the normal; but such evidence is very clearly afforded by the *Porcupine* temperature-soundings taken at various points between the latitude of Lisbon and that of the Faroe Islands, extending northwards through a range of twenty-five degrees of latitude. For while these show a considerable progressive reduction of temperature alike at the surface and in the first 100 fathoms, they also show that in the thick stratum between 100 and 700 fathoms, the reduction is so slight as we proceed northwards, that the temperature of the whole of this stratum presents a greater and greater elevation above the isocheimal of the locality,—thus clearly indicating its derivation from a southern source.

On these facts Dr. Carpenter has based a doctrine of a general oceanic circulation, sustained by the *opposition of temperature* between the Polar and Equatorial areas; which produces a disturbance of hydrostatic equilibrium sufficient to produce a *creeping flow* of a deep stratum of water from the Polar to the Equatorial area, while the superficial stratum is slowly draughted from the Equatorial towards the Polar areas. This *vertical* circulation he considers to be altogether independent of the *horizontal* circulation produced by winds, which shows itself in definite currents, of which the most notable are the Gulf Stream of the North Atlantic, and the Kuro Siwo of the North Pacific — which owe their origin to the action of the trade winds on the Equatorial portions of the Atlantic and Pacific Oceans respectively, — and the monsoon currents of the Indian Ocean. Dr. Carpenter's doctrine has thus scarcely any resemblance to that of Captain Maury, who attributed the Gulf Stream to the *elevation of level* in the intertropical area, produced by the elevation of temperature; a notion which was effectually disposed of by Sir John Herschel, who showed that no elevation of level that could be thus occasioned could possibly produce so rapid and powerful a current. And the only feature common to the two, is the existence of an underflow from the Pole towards the Equator; which Captain Maury advocated without any definite conception of the conditions under which it would be produced; while, according to Dr. Carpenter, a *vera causa* for this under-flow (as also of the complemental upper-flow in the opposite direction) is supplied by the action of Polar cold, of which the following is an experimental illustration: —

Let a long narrow trough, with glass sides, be filled with water having a temperature of 50°, and let cold be applied to the surface of the water at one end, whilst heat is similarly applied at the other. By the introduction of a colouring liquid, mixed with gum of sufficient viscidity to prevent its too rapid diffusion, it will be seen that a *vertical circulation* will be set up in the liquid; for that portion of it which has been acted on by the surface-cold, becoming thereby increased in density, falls to the bottom, and is replaced by a surface-flow, which, when cooled in its turn, descends like the preceding; and the denser water, in virtue of its excess of *lateral* pressure, creeps along the bottom of the trough towards the other end, where it gradually moves upwards to replace that which has been draughted off. As it approaches the surface, it comes under the influence of the heat applied to it; and being warmed by this, it carries along its excess of temperature in a creeping flow towards the cold extremity, where it is again made to descend by the reduction of its temperature; and thus a circulation is kept up, as long as this antagonism of temperature at the two ends of the trough is maintained. The case, in fact, only differs from that of the hot water apparatus used for heating buildings in this, — that whilst the *primum mobile* in the latter is heat applied below, which causes the water

to rise in it by the diminution of its specific gravity, the *primum mobile* of the circulation in the trough is cold applied at the surface, which causes the water to descend through the increase of its specific gravity. The application of surface-heat at the other end of the trough would have scarcely any effect *per se* in giving motion to the water; but it serves to maintain the disturbance of equilibrium, which, if cold alone were in operation, would gradually decrease with the reduction of temperature of the entire body of water in the trough, which would cease to circulate as soon as its temperature should be brought to one uniform degree of depression.

It is maintained by Dr. Carpenter, that between a column of Polar water, of which the average temperature will be below 30°, and a column of Equatorial water of an average temperature of (say) 40°, such a difference of *downward*, and therefore of *lateral*, pressure *must* exist, as will suffice to maintain a slow circulation in the great ocean-basins, corresponding to that in the trough; the heavier Polar water moving along the floor of the basin towards the Equator, and gradually rising there towards the surface, as each new arrival pushes up that which preceded it; whilst an upper stratum of lighter Equatorial water will be continually moving towards each Pole, in virtue of the indraught produced by the downward movement of the Polar column. — In this doctrine he is supported by the authority of Sir John Herschel (who addressed to him on this subject one of his last scientific letters), of Sir William Thomson, and of Sir George Airy, who all concur in sanctioning his proposition as dynamically correct.* But as his colleague, Professor Wyville Thomson, has expressed his dissent — so far, at least, as regards the cause of the amelioration of the climate of North-Western Europe — it is but fair to Dr. Carpenter to point out that his doctrine has received from the results of the *Challenger* investigations in the Atlantic, that strong confirmation which is afforded by the precise verification of a prediction. For in his later reports Dr. Carpenter gave expression to the following conclusion from the data at that time before him: —

1. That the whole mass of water in the North Atlantic below about 900 fathoms depth, will have a temperature of from 40° to 36°, this reduction depending on an inflow of Arctic water into its basin, which brings down, as in the case already cited (p. 781), a temperature which may be even below 30°; but that the limitation of the supply of this Arctic water will prevent as great reduction in the bottom-temperature of the Mid-Atlantic, as is seen elsewhere. For, putting aside what may possibly come down from Baffin's Bay, which is not likely to be much, there can be no southward underflow of Arctic water, except through the channel between Greenland and Iceland, which is not a very wide one, and the still narrower channel between the North of Scotland and the Faroe Islands; the bank which extends between the Faroe Islands and Iceland, and the shallowness of the bed of the North Sea, presenting an effectual barrier to the exit of the glacial water of the Arctic basin through those passages.

2. That, on the other hand, the unrestricted communication between the Antarctic basin and that of the South Atlantic, by allowing the free flow of Polar water over the bed of the latter, would reduce its bottom-temperature below that of the North Atlantic; and that the influence of this predominant Antarctic underflow might perhaps extend to the north of the Equator.

3. That in the Equatorial region, from which the upper warm stratum is being continually draughted off towards each pole, whilst the two Polar streams, which meet on the bottom, are as continually rising towards the surface, water below 40° would lie at a less depth beneath the surface than it does in the temperate regions of the North and South Atlantic.

Now the *Challenger* soundings taken in various parts of the Mid-Atlantic show (1) that the general temperature of the North Atlantic sea-bed, between the latitude of Lisbon and the Azores, and the tropic of Cancer, ranges from 40° Fahr. at the depth of about 900 fathoms to 35°·5 at a depth of 3,150; so that this sea-bed is overlaid by a stratum of almost ice-cold water, having an average thickness of *ten thousand feet*, which, if it has not *all* come from one or other of the Polar areas, must contain a large admixture of water that has brought with it a glacial temperature. But (2) as the *Challenger* approached the Equator, the bottom-temperature, instead of rising,

* It is further noteworthy that Pouillet, one of the greatest authorities of his time in Thermotics, had long ago (1847) expressed the opinion that a surface-movement from the Equator towards the Poles, and a deep movement from the Poles towards the Equator, would best express the facts of ocean-temperature then known; though that opinion was afterwards pushed aside for a time, by the prevalence of the erroneous doctrine of a uniform deep-sea temperature of 39°.

was found to sink still lower; 34°·4 being reached at 3,025 fathoms in the neighbourhood of St. Thomas's (lat. 18°1-2 N.), and 32°·4 at 2.475 fathoms, half-way between St. Paul's Rocks in lat. 1° N., and Fernando Noronha in lat. 5° S. Further, the temperature-section taken by the *Challenger* in crossing from Brazil to the Cape of Good Hope, shows the South Atlantic to be altogether considerably colder than the North Atlantic under the same parallels; not only the surface-temperature being lower, but the bottom being colder by from 2° to 3°. And (3) it was found, as the *Challenger* proceeded southward from the Azores, past Madeira, to the Equator, that the line of 40° progressively approached the surface, from the depth of 900 fathoms at which it lay at the Azores, to only 300 fathoms at the Equator, where the descent of the thermometer from the surface-temperature of 78° was *more rapid than in any other locality*, more than a degree being lost for every ten fathoms. That in the South Atlantic the line of 40° rises much nearer the surface than it does in the North-Atlantic,—lying in the former ocean at an average depth of only about 400 fathoms,—seems attributable in part to the general depression of its temperature, which is due to a variety of causes; the loss of heat from the surface to the 40° line, between lat. 35° S. and lat. 38° S., being only about 15°, or at the rate of one degree for every twenty-six fathoms. But it seems not improbable that the comparative warmth of the upper stratum of the North Atlantic is due to the transport of a large body of Equatorial water as far north as the parallel of 40°; not so much, however, by the *true* Gulf Stream or Florida current, as through the northward deflection, by the chain of West India Islands and the Peninsula of Florida, of that large portion of the Equatorial current which strikes against them without entering the Caribbean Sea at all.

We are thus led to the question which is very fully discussed both in Dr. Carpenter's last report, and in Chapter VIII. of Professor Wyville Thomson's book, as to the influence of the Gulf Stream upon the climate of North-Western Europe; and this is a subject of such general interest, that, as there is a decided difference of opinion between these two authorities, our readers will naturally desire to know the precise nature of the doctrine advocated by each, and the principal arguments on which it rests.

It is admitted on both sides that the climate of the western shores of the British Islands, still more that of the Shetlands and the Faroes, and yet more again that of the northern part of the Norwegian coast, of the north coast of Russia, at least as far as the entrance of the White Sea, and even of Iceland and Spitzbergen, is ameliorated by a north-east flow of surface-water, bringing with it the warmth of a lower latitude. For although Mr. Findlay in this country, and Dr. Hayes (the Arctic explorer) in the United States, have attributed this amelioration to the prevalence of south-west winds alone, yet the recent correlation of a large body of comparative observations on the winter temperature of the sea and of the air has clearly shown that the former — as we proceed north — has so much higher an average than the latter, as to be clearly independent of it. Now Professor Wyville Thomson accepts the current doctrine that this north-east flow is an extension of the Gulf Stream, using that term, however, to include, with the *true* Gulf Stream or Florida current, the portion of the Equatorial current which never enters the Gulf of Mexico; and he considers that the whole of that vast body of water, extending downwards to at least 600 fathoms, which the temperature-soundings of the *Porcupine* have shown to be slowly creeping northwards (p. 782), is impelled by the *vis a tergo*, or propulsive force imparted to the Equatorial current by the trade-winds. That this propulsive force here extends itself downwards to a depth far greater than that of either the Equatorial or the Gulf Stream current, he attributes to the recollection of its waters in the *cul de sac* formed by the north-eastern corner of the Atlantic, and the gradual narrowing of the channel through which it is impelled. But this is entirely inconsistent with the fact, shown in his own chart of Dr. Petermann's isothermal lines, that the northward movement extends *all across the Atlantic*, from the coast of Ireland to Newfoundland; the isotherms there turning sharply round the corner, and running to the north, and even to the north-west, in a manner that cannot possibly be accounted for by the propulsive force which is carrying the *real* Gulf Stream nearly due east. In fact, Professor Wyville Thomson seems to us to have fallen into the error of his leader Dr. Petermann and other physical geographers, in assuming that the proved excess of temperature in the Arctic area

can be due to nothing else than "the Gulf Stream." If, by this term, they avowedly mean nothing else than a northward movement of warm water from the Mid-Atlantic, we are entirely at one with them, only deprecating the application of the term "Gulf Stream" to that movement, as leading to a misconception. But if they distinctly attribute it, with Professor Wyville Thomson, to the action of the trade-winds, we ask them for some intelligible *rationale* of the manner in which the trade-wind circulation drives northwards into the Polar area a body of water more than 2,000 miles wide and 700 fathoms deep.

Dr. Carpenter, on the other hand, who finds a definite *vera causa* for this movement in the indraught of the whole *upper* stratum of the North Atlantic into the Polar area as complemental to the outflow of its *deeper* stratum, — has been led by a careful investigation of all accessible data as to the volume, temperature, and rate of movement of the *true* Gulf Stream in various parts of its course, to adopt the view previously advocated by Mr. Findlay, and accepted by Sir John Herschel and Admiral Irminger (of the Danish navy), that the Florida current — which gradually spreads itself out like a fan, diminishing in depth as it increases in extent — is practically broken up and dispersed in the Mid-Atlantic, not long after passing the banks of Newfoundland; so that if any of its extensions really reach our shores, they bring with them little or no warmth. Even at its deepest and strongest, this powerful current loses 15° of surface-temperature during its winter passage to the longitude of Nova Scotia, which occupies from forty to fifty days. And when it reaches the banks of Newfoundland it encounters the Labrador current, with its fleet of icebergs, by which its temperature is still further greatly reduced; and as its superficial area increases, its depth diminishes, so that it becomes less and less able to maintain its temperature against the cooling influence of the air above it. As its rate of movement, where it is last recognizable as a current, is so reduced, that at least 100 days must be occupied in its passage from the banks of Newfoundland to the Land's End, it is scarcely to be conceived that a thinned-out surface layer of only fifty fathoms' depth, should do otherwise than *follow* the temperature of the atmosphere above it, as the thin super-heated layer of the Mediterranean most certainly does. The continuance of its north-east movement as a surface-drift, bearing with it trunks of tropical trees, fruits, floating shells, &c., is fully accounted for by the prevalence of south-west winds over that portion of the Atlantic, which land these products on the shores it washes. Further, of that *outside* reflection of the Equatorial current which is included by Professor Wyville Thomson under the term Gulf Stream, the main body appears to cross the Atlantic near the parallel of the Azores, and to turn southwards when it has passed them, being drawn back as a "supply-current" towards the sources of the Equatorial; and this seems to be the final destination of the greater part of the Florida current itself; only one small branch of it being occasionally recognizable in the Bay of Biscay as Rennel's current, while two other narrow bands can be distinguished by their somewhat higher temperature, one between the Shetland and the Faroe Isles, and the other between the Faroes and Iceland.

The real *heater* of North-Western Europe, according to Dr. Carpenter, is the stratum of 600 to 700 fathoms depth, which, as already mentioned (p. 782), he has traced northwards by continuity of temperature from the coast of Portugal to the Faroe banks, and the movement of which he attributes to a *vis a fronte*, or indraught, resulting from the continual descent, in the Polar area, of the water whose temperature has been brought down by surface-cold, — as in the experimental illustration, of which his account has been already cited (p. 782). The surface-temperature of this stratum, in the summer months, follows that of the air, which is generally warmer than itself; but in the winter, when the temperature of the air falls below that of the sub-surface stratum, each surface-film, as it is cooled and descends, will be replaced by warmer water from below; and thus, as Dr. Carpenter points out, a deep, moderately warm stratum becomes a much more potent heat-carrier than a mere surface-layer of superheated water. Hence it is the 700 fathoms' depth, in the North Atlantic, of the stratum having a temperature above 45°, which gives to this slow-moving mass its special calorific power. In corresponding latitudes of the South Atlantic, on the other hand, the stratum exceeding 45° of temperature is not more than 300 fathoms deep; so that if this stratum be moving towards the South Pole, its power of ameliorating the Antarctic climate will be much infe-

rior. To whatever extent, therefore, the greater depth of the stratum above 45° in the North Atlantic is due to the prolongation into it of the Equatorial current (a matter still open to investigation), to that extent Dr. Carpenter admits our obligation to it; but he argues that a cause for its northward flow must be sought somewhere else than in the original *vis a tergo* of the *horizontal* circulation, which will tend, if not exhausted, to bring it back to its source; and that this cause is to be found in the *vis a fronte* of the *vertical* circulation, of which the *primum mobile* is Polar cold.

The decision of this question will ultimately rest mainly on the temperature-phenomena of high southern latitudes, to which no Gulf Stream brings warm water from the Equatorial source; and as the *Challenger* was ordered (at Dr. Carpenter's special instance) to run due south from Kerguelen's Land, so as to approach the great ice-barrier of the Antarctic as nearly as may be deemed expedient, and as we have already heard from Melbourne that she has done, we shall learn ere long whether the upper stratum of the Southern Ocean is really travelling polewards, as on Dr. Carpenter's theory it ought to do, and as the slow southernly "set" noticed by several Antarctic navigators would seem to indicate that it does. In the mean time, however, we may notice that a remarkable confirmation of Dr. Carpenter's doctrine of a continual upward movement of water in the Equatorial zone, from the bottom towards the surface, is afforded by the *Challenger* observations. For this ascent is indicated, not only by the remarkable approach of the isotherm of 40° to within 300 fathoms at the Equator, but also by the marked reduction of the salinity of the surface-water, which is there encountered. For the *Challenger* observations, confirming others previously made, show that the specific gravity of *surface*-water (allowance for temperature being duly made) falls within the Tropics from an average of 1027·3 to an average of 1026·3; and that this reduced salinity corresponds exactly with that of the low salinity of the Polar water which is traceable over the sea-bed even into the Equatorial area.

It is obvious that such a continual ascent of glacial water towards the surface, must have a moderating effect upon the surface-temperature of the Equatorial zone; and it seems to us that this doctrine of a *vertical* oceanic circulation affords an adequate *rationale* of the fact, that the surface-temperature of the deep ocean seems never to rise much above 80°, even where (as under the Equator) it is constantly exposed to the most powerful insolation. In the Mediterranean and the Red Sea, in which there is, *ex hypothesi*, no such upward movement, the surface-temperature is proportionally much higher; that of the Mediteranean in lat. 35° being nearly equal in September to that of the Equatorial Atlantic in the same month, and that of the Red Sea rising to 92°. So also, along the Guinea coast, where the depth is not great enough to admit the glacial under-flow, the surface-temperature sometimes rises as high as 90°. Thus it appears that this general oceanic circulation exerts as important an influence in *moderating tropical heat*, as in tempering Polar cold.

That the constantly renewed disturbance of equlibrium produced by difference of temperature, is adequate to maintain such a slow *vertical* oceanic circulation as Dr. Carpenter contends for, seems now established by the proved existence of decided *under-currents* in the Gibraltar and Black Sea straits, which are pretty clearly maintained by slight differences of downward and therefore lateral pressure between equal columns at the two extremities of each strait. In the case of the Gibraltar currents, the superficial indraught of Atlantic water into the Mediterranean serves to keep up the level of that great inland sea, which would otherwise be lowered by excessive evaporation.* But this indraught, which replaces by salt water what has passed off as fresh, would produce a progressive accumulation of salt in the Mediterranean basin, if it were not compensated by an under-current in the opposite direction, which carries *out* as much salt as the surface-current brings *in*; and the maintaining power of this under-current, which sometimes runs at the rate of a mile and a half per hour, is the excess of the average specific gravity of Mediterranean water, which may be taken as 1029, over that of Atlantic water, which may be taken as 1027·3.—The case is still more striking, however, in regard to the currents of the Dardanelles and the Bosphorus, where the conditions are reversed, and the difference in density between the columns is greater. For in consequence of the excess of

* See Dr. Carpenter's Paper "On the Physical Conditions of Inland Seas," in *The Contemporary Review*, vol. xxii., p. 386.

fresh water brought down by the great rivers which discharge themselves into the Black Sea, above the loss by evaporation from its surface, there is generally an *outward* upper-current,— which, however, owes part of its force to wind,— setting first into the sea of Marmora, and thence into the Ægean. Now the salinity of Black Sea water is reduced by the excessive influx of fresh water, to less than half that of the Mediterranean; its specific gravity usually varying between 1012 and 1014, according to the season. And it was argued by Dr. Carpenter that, alike on *à priori* and *à posteriori* grounds, there *must* be a powerful inward under-current: since the great excess of lateral pressure at the outer end of each strait would necessarily drive inwards the lower stratum of its water; while the salt, if not thus continually returned, would be gradually altogether washed out of the Black Sea basin. To this it was replied by Captain Spratt, who had surveyed these straits some years ago, and who strongly opposed the whole under-current doctrine, *first*, that he had ascertained their bottom-water to be stationary, and *second*, that the salt which passes *outwards* during a large proportion of the year, is carried *inwards* again during the winter months, when the Black Sea rivers are low, and the wind sets *to* the north-east, instead of *from* it as at other times. Having reason, however, to distrust the accuracy of Captain Spratt's conclusions, as well from an examination of his own record of his experiments, as from local information which was strongly corroborative of the existence of an under-current, Dr. Carpenter requested the Hydrographer to the Admiralty to direct that a re-examination of this question should be made by the surveying staff of the *Shearwater*, which was about to proceed to that station; and the result was that most unequivocal evidence was obtained of the existence of an inward under-current, of which the strength is proportional to that of the outward upper-current; being greatest when the latter is impelled by a north-east wind, which, by lowering the interior and raising the exterior level, will increase the preponderance of the outer column over the inner. When the *outward* surface-current was running at a rate of from three to four knots an hour, the buoy from which the current-drag was suspended in the deeper stratum was carried *inwards* by its movement, at a rate greater than that at which any row-boat could keep up with it; so that the apparatus would have been lost, if the steam-launch of the *Shearwater* had not been able to follow it.

This very striking confirmation of Dr. Carpenter's prediction will probably increase our readers' confidence in the soundness of the general physical theory he propounds; which is to the effect that wherever two bodies of water are in connection with each other, constantly differing in downward pressure,— whether in consequence of difference of temperature, excess of evaporation, or inflow of fresh water,— there will be an under-flow from the heavier towards the lighter, which, by lowering the level of the former, will produce a return upper-flow from the lighter towards the heavier. This, as Sir John Herschel remarked, seems the common-sense of the matter; and it is only because the Gulf Stream has a body of staunch advocates, like Dr. Petermann, Professor Wyville Thomson, and Mr. Croll, who strenuously uphold the exclusive agency of the trade-winds, that any opposition has been raised to Dr. Carpenter's views. Professor Möhn of Christiania, who wrote a very important Memoir in 1872 to prove the dependence of the peculiar climate of Norway upon the Gulf Stream,— his facts *really* proving its dependence upon the flow of *warm water* to the Norwegian shores,— has since expressed to Dr. Carpenter his conversion to Dr. C.'s doctrine of the cause of that flow. And by Dr. Meyer, who has been for some years engaged in the investigation of the currents of the Baltic (the condition of which, as regards excess of river-supply over evaporation, corresponds with that of the Black Sea), they are unhesitatingly accepted as entirely accounting for the phenomena he has there observed.

In another very important particular do the results of the *Challenger* observations confirm Dr. Carpenter's previously expressed views,— namely, that the *cold band* which intervenes between the Gulf Stream and the Atlantic seaboard of the United States, and which is traceable even along the northern side of the Florida Channel itself, is really produced by the surging-upwards of the Polar-Equatorial flow which underlies the Gulf Stream, and which, as the temperature-soundings of the United States coast surveyors have shown, even enters the Gulf of Mexico as an under-current flowing inwards beneath the warm outflowing stream. This surging-upwards of the

deeper cold strata along the western slope of the Atlantic basin is easily accounted for on dynamical principles, and does, in fact, afford very cogent evidence that the great body of North Atlantic water below (say) 800 fathoms is really moving southwards. It was first pointed out, we believe, by Captain Maury, that the *eastward* tendency of the Gulf Stream, which shows itself more and more as it advances into higher latitudes, is due in great part to the *excess* of easterly momentum which it brings from the intertropical zone, where the earth's rotatory movement is much more rapid than it is half way towards the Pole; and this view of the case was fully accepted by Sir John Herschel. For the same reason, any body of water moving from either Pole towards the Equator will bring from higher to lower latitudes a *deficiency* of easterly momentum, that is to say, it will tend *westwards;* and this tendency will carry it towards the surface, when it meets the slope of the United States seaboard. The correctness of this view has been further confirmed (1) by the fact recently communicated to Dr. Carpenter by Captain St. John, who has lately returned from the survey of the Japan Sea, that a similar cold band intervenes between the Kuro Siwo (p. 782) and the eastern coast of Japan; and (2) by the results of the inquiries prosecuted in the Baltic and North Sea by Dr. Meyer, who has found distinct evidence of the surging-up of the southward-moving deeper and colder layer on the western slopes of those basins; the temperature of the eastern face of the Dogger Bank being from 10° to 15° lower than that of its western, and a difference of 15° sometimes showing itself within five fathoms of depth.

We come lastly to the biological results of these explorations, and the bearings of these on several most important points of bio-geological doctrine,—as, for example, the existing distribution of marine animal life in its relation to depth, temperature, and supply of food and oxygen; its connection with anterior changes in the relations of sea and land, and in the depth and temperature of the sea-bed; the continuity of life in some localities, whilst interruptions occurred in others; and the question how far a gradual change in external conditions may modify the characters of species, so as to sanction that idea of "descent with modification" which seems increasingly to find favour among unprejudiced palæontologists. On each of these points we shall briefly touch.

Previously to the commencement of the recent series of researches, our knowledge of the animal life of the deep sea was limited to that which could be derived from the examination of the small samples of bottom brought up by the sounding apparatus; the use of the dredge having been restricted to depths of about 400 fathoms. These samples indicated the very extensive diffusion of low and simple forms of animal life, belonging for the most part to the group of foraminifera. Only a few specimens of any higher type had been obtained, and the opinion was very generally entertained that the existence of such was impossible under the enormous pressure to which they would be subjected at great depths, and that the specimens brought up by the sounding-line (as in the case of the star-fishes which Dr. Wallich found clustering around it) had been entangled by it in its passage through the upper stratum. It seems to have been forgotten, however, that this pressure, being equal in all directions, can have but a very trifling influence on the condition of animals composed entirely of solid and liquid parts; neither altering their shape, interfering with their movements, nor obstructing any of their functions. A drop of water (as Dr. Carpenter pointed out in his first report) enclosed in a globular membranous capsule of extreme tenuity, would undergo no other change beneath a fluid pressure of three tons on the square inch, than a very slight reduction of its bulk; and if an aperture existed in the capsule, its contents would not escape, since, while the external pressure would tend to force them out, an inward pressure of exactly equivalent amount would tend to keep them in.

The dredgings carried on in the *Porcupine*, in the summer of 1869, on the eastern slope of the North Atlantic Basin, between the latitudes of 48° and 60° north, clearly showed that the supposed limitation of higher forms of animal life to a depth not much exceeding 300 fathoms (an inference deduced by Edward Forbes from his dredgings in the Ægean) has no real existence—at least so far as relates to the oceanic area; a varied and abundant fauna having been met with in successive explorations, progressively carried down to 600, 800, 1,000, 1,200, 1,500, 1,700 fathoms; and when at last the dredge was sent

down to a depth of 2,435 fathoms, it came up loaded with a hundredweight and a half of "globigerina-mud"—a large part of which was a mass of life, having imbedded in it representatives of nearly all the principal types of marine invertebrata. And we understand that many of the dredge-hauls taken in the *Challenger* expedition, at yet greater depths, have been not less prodective. Hence it appears that no *zero* of depth can be specified, at which animal life must cease. The distribution of that life, however, is obviously much influenced by temperature; as was most strikingly proved by the marked difference between the faunæ of the warm and the cold areas, already pointed out (p. 778), and by the fact that boreal forms were traced far southwards, on the deep cold sea-bed, although not found in shallower waters. Not less striking was the *dwarfing* of some of our common British star-fishes that presented themselves in the cold area; and it seems probable, therefore, that the small size of most of the abyssal forms is due as much to reduction of temperature, as to any other condition. Of the extent of the addition to zoological knowledge which it may be expected that the exploration of the deep sea will afford, some idea may be derived from the fact that the four months' dredgings of the *Porcupine*, in what may be accounted British seas, added 117 species of testaceous mollusca (about one-fourth of the previous total) to our fauna; 56 of these being new to science, besides 7 known only as Tertiary fossils.

But to this downward extension of animal life, a most remarkable exception has been found to exist in the case of the Mediterranean. While the *Porcupine* dredgings of 1870, off the coast of Portugal, were attended with remarkable success,—in one instance as many as 180 species of shells, of which 71 were previously undescribed, and 24 known only as fossils, coming up in one haul—those taken soon afterwards in the deep water of the Mediterranean were singularly barren. Dredge after dredge came up loaded with a tenacious mud, the most careful sifting of which gave no organic forms whatever, not even minute foraminiferal shells. Within the depth of 300 fathoms, however, both along the African coast, and on the Adventure and Skerki Banks dividing the eastern from the western basin (p. 774) there was no paucity of animal life. A similar result was obtained about the same time in the Adriatic, by Oscar Schmidt; and the statement of Edward Forbes, in regard to the *zero* he met with in the Ægean, was thus unexpectedly confirmed. Thus the nearly *azoic* condition of the deeper part of the Mediterranean and its two extensions, as compared with the abundance of animal life met with at similar depths in the open ocean, obviously points to some peculiarity in the physical condition of the former sea, which differentiates it from the latter.

The question as to the nature of this peculiarity is one of great interest; for the existence of vast thicknesses of sedimentary strata almost or altogether destitute of organic remains, has been one of the standing puzzles of geology, which Edward Forbes's limitation of animal life to 300 fathoms, was supposed to have solved, by relegating these deposits to seas too deep to allow of the existence of animals on their bottom. But this explanation having been found untenable, a new solution had to be sought; and this is offered by Dr. Carpenter as a corollary from his general proposition as to the sustentation of a vertical oceanic circulation by thermal agency alone. For if this proposition be accepted, it follows that every drop of oceanic water is brought to the surface in its turn, and is thus exposed to the vivifying influence of prolonged contact with the atmosphere. But from participating in the oceanic circulation the Mediterranean is excluded, by the shallowness of the ridge which separates it from the Atlantic; and the uniformity of its temperature from 100 fathoms downwards precludes the existence of any thermal circulation of its own, which would have the effect of bringing its abyssal water to the surface. That water being shut in by walls which rise 10,000 feet from its bottom, it is difficult to conceive of any agency that can disturb its stillness; and thus it comes to pass that the very fine sedimentary particles brought down by the Nile and the Rhone, being diffused by superficial currents—before they have time to subside—over the entire area, slowly gravitate to the bottom, giving such a turbidity to the lowest stratum, as must be very unfavourable to the existence of most forms of marine animals. But this is by no means all. This sediment includes a large proportion of organic matter, the slow decomposition of which will use up the oxygen, and replace it by carbonic acid; while the absence of any

vertical circulation will prevent that aërating process, which, in the open ocean, furnishes the corrective. In his second visit to the Mediterranean, Dr. Carpenter tested the correctness of this surmise by an analysis of the gases boiled off from the bottom-water; and he found that, using the method which had been previously employed in the examination of the gases of the bottom-water of the Atlantic, the reduction of oxygen and the excess of carbonic acid were most unmistakable. This result is of peculiar interest, now that Professor Ramsay is advocating the doctrine that the Red Sandstones, alike of the old and of the new series, were deposited in inland seas. Every geologist knows that while there are certain beds of these which are rich in fossils, their general character is barrenness. And it may well be, as Dr. Carpenter points out in regard to the Tertiaries of Malta, that the former were the shallow-water formations, whilst the latter, composed of a finer sediment, were deposited at the bottom of a deep basin.

Furthermore, the doctrine of a vertical oceanic circulation helps us to account for the universal diffusion of food-supply, without which abyssal life could not be supported. Vegetation, which requires light for its power of generating organic compounds, and thereby providing nutriment for animals, cannot exist where light is not; and even the stony pink Nullipores are not found below about 300 fathoms, whilst the foliaceous sea-weeds are for the most part limited to half that depth. Now the cod which our fishermen catch on the Faroe Banks, resort thither to feed upon the star-fish and other marine animals which abound there; and these animals, in their turn, feed upon the globigerinæ which cover the sea-bed; so that *we* may be said really to live indirectly upon globigerinæ. But on what do the globigerinæ themselves live? The question is thus answered — we believe correctly — by Professor Wyville Thomson: —

> All sea-water contains a certain quantity of organic matter, in solution and in suspension. Its sources are obvious. All rivers contain a considerable quantity. Every shore is surrounded by a fringe which averages a mile in width, of olive and red sea-weed. In the middle of the Atlantic there is a marine prairie, the "Sargasso Sea," extending over 3,000,000 square miles. The sea is full of animals, which are constantly dying and decaying. The amount of organic matter derived from these and other sources by the water of the ocean is very appreciable. Careful analyses of the water were made during the several cruises of the *Porcupine*, to detect it, and to determine its amount; and the quantity everywhere was capable of being rendered manifest and estimated; and the proportion was found to be very uniform in all localities and at all depths. Nearly all the animals at extreme depths — practically all the animals, for the small number of higher forms feed upon these — belong to one subkingdom, the Protozoa; whose distinctive character is that they have no special organs of nutrition, but absorb nourishment through the whole surface of their jelly-like bodies. Most of these animals secrete exquisitely formed skeletons, some of silica, some of carbonate of lime. There is no doubt that they extract both these substances from the sea-water; and it seems more than probable that the organic matter which forms their soft parts is derived from the same source. It is thus quite intelligible that a world of animals may live in these dark abysses, but it is a necessary condition that they must chiefly belong to a class capable of being supported by absorption through the surface of their bodies of matter in solution, developing but little heat, and incurring a very small amount of waste by any manifestation of vital activity. According to this view it seems probable that at all periods of the earth's history some form of the Protozoa — rhizopods, sponges, or both — predominated greatly over all other forms of animal life in the depths of the warmer regions of the sea. The rhizopods, like the corals of a shallower zone, form huge accumulations of carbonate of lime; and it is probably to their agency that we must refer most of those great bands of limestone which have resisted time and change, and come in here and there with their rich imbedded lettering to mark like milestones the progress of the passing ages. (p. 48.)

It is obvious, therefore, that, as was long since pointed out by Edward Forbes, who is justly lauded by Professor Wyville Thomson ("Depths of the Sea," p. 6) as the pioneer in this inquiry — "the only means of acquiring a true knowledge of the *rationale* of the distribution of our present fauna is to make ourselves acquainted with its history, to connect the present with the past." Of this our author gives us a most striking illustration in the comparison instituted by Mr. Alexander Agassiz between the *Echinidea* or sea-urchins on the Pacific and Atlantic sides of the Isthmus of Panama. For while the *species* found on these two sides respectively are distinct, they belong almost universally to the same *genera*; and in most cases each genus is represented by species on each side,

which resemble one another so closely in habit and appearance as to be at first sight hardly distinguishable.

Supposing species to be constant, this singular chain of resemblances would indicate simply the special creation on the two sides of the Isthmus of two groups of species closely resembling one another, because the circumstances under which they were placed were so similar; but admitting "descent with modification," while gladly availing ourselves of the convenient term "representation," we at once come to the conclusion that these nearly allied "representative species" must have descended from a common stock, and we look for the cause of their divergence. Now, on examining the Isthmus of Panama, we find that a portion of it consists of Cretaceous beds, containing fossils undistinguishable from fossils from the Cretaceous beds of Europe; the Isthmus must therefore have been raised into dry land in Tertiary or Post-tertiary times. It is difficult to doubt that the rising of this natural barrier isolated two portions of a shallow-water fauna which have since slightly diverged under rather different conditions. I quote Alexander Agassiz: "The question naturally arises, have we not in different faunæ on both sides of the Isthmus a standard by which to measure the changes which these species have undergone since the raising of the Isthmus of Panama and the isolation of the two faunæ?" (p. 14.)

Few zoologists, we apprehend, will now dissent from this conclusion; for it is a principle accepted by all philosophical naturalists, that the more extensive the range of comparison, the wider is found to be the range of variation of specific types; so that forms which might be supposed to have had an originally distinct parentage, if only their most differentiated types be compared, are found, by the gradational character which shows itself when the comparison is instituted among a large number of intermediate types, to be genetically identical. Numerous instances of this kind have presented themselves in the study of the *Porcupine* dredgings. Thus certain sea-urchins of the Northern seas and of the Mediterranean, which have been accounted as belonging to distinct species, were found by Professor Wyville Thomson to be so gradationally connected with each other by the intermediate forms dredged along the West of Ireland, the Bay of Biscay, and the coast of Portugal, that the specific distinction altogether breaks down. And Professor Duncan, who has examined the corals, has found not only reputed *species*, but reputed *genera*, to be specifically identical; the two forms growing as branches from the same stem. Now, as was long since laid down by Edward Forbes, species which have a wide area of *space*-distribution, have a similarly prolonged distribution in *time*; their capacity of adaptation to change of conditions operating equally in both cases. And it is just where this capacity of adaptation is the greatest, that departures from the primitive type show themselves most strongly; such departures (which often come to be so fixed and constant that they might well be accounted specific characters) being simply the results of the *pliancy* of the organism, which can adapt itself to changes of external conditions, instead of succumbing to them.

Keeping this principle in view, we now proceed to those yet more remarkable cases, in which types of animal life, which were characteristic of former geological periods, and which, from not occurring in shallow waters, were supposed to have altogether died out, have been discovered to be still holding their ground in the deep sea. Mention has been already made of this in the case of certain Tertiary shells; but there are other cases even more striking. The deep-sea explorations of our own countrymen may indeed be said to have originated in the discovery, by M. Sars junior (son of the late eminent Professor of Zoology at Christiana, and himself Inspector of Fisheries to the Swedish Government), at a depth of nearly 400 fathoms, off the Lofoden Islands, of a small crinoid, differing in the most marked manner from any crinoid known to exist at the present time, but clearly belonging to the *Apiocrinite* family, which flourished in the Oolitic period, — the large pear-encrinite of the Bradford Clay being its most characteristic representative, while the *Bourgueticrinus* of the Chalk seemed to be its latest. To Professor Wyville Thomson and Dr. Carpenter, who had been conjointly making a special study of this group, it was clear that the little *Rhizocrinus* of Professor Sars was a dwarfed and deformed representative of the Apiocrinite type, which might be fairly regarded as a degenerate descendant of the old pear-encrinite; and this encouraged them in the belief, on which they based their application for Government aid, that a large number of such ancient types might probably be found, by carrying down the exploration of the bottom by the dredge to a depth not previously thus examined. This expectation was fully justi-

fied by the result. For in their first (*Lightning*) cruise they not only found that the layer of globigerina-mud, previously brought up by the sounding-line from the surface of the sea-bed, has a thickness to which no limit can be assigned, and that in every particular the whole mass resembles chalk in the process of formation, as had been previously stated by Bailey (U.S.), Huxley, Wallich, and others, in regard to the small samples they examined; but they further discovered that this bears on its surface a number of types of animals whose *facies* is essentially that of the Cretaceous period. The most remarkable of these was a beautiful siliceous sponge, so closely corresponding in general structure with the *ventriculites* of the Chalk, that no doubt could be entertained of the intimacy of their relationship. The interest excited among zoologists and palæontologists by this discovery, powerfully reinforced that which had been called forth among physicists and physical geographers by the temperature-observations taken during the same cruise; and this was fully sustained by the discoveries of the next year. For the number of Echinidan forms, peculiarly characteristic of the old Chalk, that were met with in the *Porcupine* cruises of 1869 — several of which are described and beautifully figured in Professor Wyville Thomson's pages — surpassed all expectation; and some of these, as the singular "chain-mail" urchin *Calveria hystrix*, perpetuate special Cretaceous types, which were supposed to have long since died out. The results of the dredgings simultaneously carried on by Count Pourtales in the Florida Channel, have proved singularly accordant in this particular with those obtained by our British explorers; the general character of the Echinoderm fauna there met with, bearing a singular resemblance to that of the old Chalk, although without any identity of species; and the *Ananchytes*, one of the commonest of the Cretaceous urchins, whose type had been regarded as altogether extinct, being distinctly represented by the newly-discovered form (also included in the *Porcupine* collection) which Mr. Alexander Agassiz has described under the name *Pourtalesia*.

These facts afford a most remarkable confirmation to the doctrine of Professor Wyville Thomson, propounded in Dr. Carpenter's first report,— that the formation now going on upon the North Atlantic sea-bed is not a *repetition*, but an absolute *continuation*, of the Cretaceous; the deposit of globigerina-mud over that area having never been interrupted during the whole of the Tertiary period. The physical grounds for the belief that there has been no such change in the Atlantic basin during the whole of that period, as would have converted its bottom into dry land, have been already pointed out (p. 776); and if it has remained a deep-ocean basin during that time, it is obvious that while an interrupted succession of Tertiary deposits, imbedding terrestrial, fresh-water, estuarine, and *shallow*-water marine faunæ, was formed on the borders of that basin, where slight differences of level would alter the whole distribution of land and sea, an unbroken series of layers of a substance resembling the old Chalk in every essential particular, would have been formed by the continued activity of protozoic life over the newest beds of what we are accustomed to call the "Cretaceous formation," entombing a *deep*-sea fauna, which would preserve the general *facies* of the Cretaceous, whilst differing from it in detail, as that of the upper beds of our Chalk formation differs from that of the lower. By Sir Charles Lyell it is maintained that we must regard the Cretaceous period as having come to an end with the elevation of the Chalk of Europe, and with the disappearance of the *higher* types of the Cretaceous fauna, such as its characteristic fishes and chambered Cephalopods. But Mr. Prestwich has supplied an adequate *vera causa* for this extinction, in the establishment at this period of a free communication between the Polar area and the Cretaceous sea, which he regards (on quite independent grounds) as having been previously cut off from it by an intervening continent. The reduction of temperature thus produced would have killed off all the inhabitants of the upper waters which were dependent on a warmth approaching the tropical; whilst those which could adapt themselves to the change would have maintained their ground (with more or less of modification in structure), and would in turn leave their remains to be entombed in the ever-accumulating mass of globigerina-mud. That scarcely any of the molluscs, echinoderms, or corals of the present deposit can be *specifically* identified with those of the old Chalk, is exactly (as is justly remarked by Professsor Wyville Thomson) what might be fairly expected, in consideration of the various changes which must have occurred since the commence-

ment of the Tertiary epoch, in the various conditions of their existence. "The utmost which can be expected is the persistence of some of the old generic types, with such a resemblance between the two faunæ as to justify the opinion that, making due allowance for emigration, immigration, and extermination, the later fauna bears to the earlier the relation of descent with extreme modification."

We must content ourselves with indicating another very important bearing which these deep-sea researches must have upon geological theory — the modification they necessitate of the *glacial* doctrine. For it now becomes obvious, as Dr. Carpenter pointed out in his second report, that as the climate of the sea-bottom has no relation whatever to that of the land (a glacial temperature now prevailing over the Equatorial sea-bed), the presence of Arctic types in any marine formation can no longer be accepted as furnishing evidence *per se* of the general extension of glacial action into temperate or tropical regions. If, as Dr. Carpenter maintains, the underflow of Polar water towards the Equator is sustained by the disturbance of equilibrium produced by thermal agency alone, then such an underflow must have taken place in all geological periods, provided that there existed a free and deep communication between the Polar and the Equatorial areas. By Professor Wyville Thomson, on the other hand, it is maintained that the Polar underflow is the result of the deflection of the Equatorial current, by the opposition of land, northwards and southwards, so as to occasion an indraught which this underflow tends to fill; and on this hypothesis, if there were a free passage for the Equatorial current through Central America into the Pacific, as there would be no Gulf Stream, there would be no Polar underflow; so that in any former geological period in which any such conditions may have existed, the temperature of the Equatorial sea-bottom would not have been depressed, however free may have been its communication with the Polar areas. This is tantamount to saying that an enormous disturbance of fluid equilibrium must have been constantly in existence, without producing any movement — a proposition which no mechanical philosopher can accept.

We cannot more appropriately conclude this exposition, than by the following citation from the lecture at the Royal Institution (April 9, 1869), in which Dr. Carpenter presented to the public the results of the tentative *Lightning* cruise of the previous year: —

The *facts* I have now brought before you still more the *speculations* which I have ventured to connect with them, may seem to unsettle much that has been generally accredited in geological science, and thus to diminish rather than to augment our scock of positive knowledge; but this is the necessary result of the introduction of a *new idea* into any department of scientific inquiry. Like the flood which tests the security of every foundation that stands in the way of its onward rush, overthrowing the house built only on the sand, but leaving unharmed the edifice which rests secure on the solid rock, so does a new method of research, a new series of facts, or a new application of facts previously known, come to bear with impetuous force on a whole fabric of doctrine, and subject it to an undermining power which nothing can resist, save that which rests on the solid rock of truth. And it is here that the moral value of scientific study, pursued in a spirit worthy of its elevated aims, pre-eminently shows itself. For, as was grandly said by Schiller in his admirable contrast between the "trader in science" and the "true philosopher," — "New discoveries in the field of his activity which depress the one enrapture the other. Perhaps they fill a chasm which the growth of his ideas had rendered more wide and unseemly; or they place the last stone, the only one wanting to the completion of the structure of his ideas. But even should they shiver it into ruins, should a new series of ideas, a new aspect of nature, a newly discovered law in the physical world, overthrow the whole fabric of his knowledge, *he has always loved truth better than his system*, and gladly will he exchange her old and defective form for a new and fairer one."

From Chambers' Journal.

THE MANOR-HOUSE AT MILFORD.

CHAPTER IX.

'Tis better to be vile than vile esteemed.

FREWEN wildly raged when he heard of Tom Rapley's misfortune, and his own involvement as surety, denounced his folly in doing a good turn for any one, and would not hear of any suggestion that, after all, it was possible Tom had been really robbed. He caused Tom to be brought before him in his private office, and spoke to him in a terrible voice. He would listen to no excuse or explanation. "Find that money, sir, by four o'clock to-day, or to prison you go."

And the lawyer was not indulging in a vain threat. There was a meeting of magistrates that day at Biscopham. Mr. Frewen, who attended there in his capacity of clerk to the bench, mentioned to them the apprehended defalcation at Milford. At his request, they signed a warrant of commitment, to be executed if the money were not paid over before the bank closed. With knowledge of this in their minds, the police were not likely to exert themselves strenuously to find out the alleged robber of Tom Rapley's gold. The superintendent, indeed, took down from his lips a statement of the circumstances under which he lost the money. But when Tom came to describe the place where he had hidden the gold, he hesitated, and gave a very vague account of it. For it occurred to him all of a moment: "If this money is really gone, and I go to prison, it will be a bit of comfort to know that Lizzie has a roof over her head, and ten shillings a week to keep her from starvation." Now, if he disclosed the fact, that he had been roaming about in the empty house, and that they had broken an entrance into it, Frewen would assuredly turn them all out without the shortest respite. The practised ear of the police-officer detected the doubt and equivocation in Tom's narrative.

"Just so," he said, looking fixedly at Tom when he had finished his story. "I have no doubt we shall have the man who took the money in custody before dark. I think we know him."

"And will you get the money back?" cried Tom, plucking up a little heart for the moment at this cheering news.

"I should think you know best about that."

Something in the man's manner told Tom what he really meant — that they would have Tom himself in custody ere night. He had been experiencing that hard incredulous manner all the morning, and had accustomed himself to look for suspicion, till at last he almost imagined that he must really be the rogue that everybody persisted in believing him. There was only one person in the whole of Biscopham to whom he could go with any hope of having his story credited, or gaining any sympathy, and that was Emily Collop.

To Collop's shop he went, and into the little low-pitched room over the shop, redolent of corduroys and fustians. Emily hadn't heard the story as yet. Tom told her the whole, and she listened with knitted brows. "Is there anybody whom you can suspect?" she said.

"Then you believe me?" cried Tom. "You don't think, as other people do, that I've taken the money myself?"

"Of course, I believe you, Tom. Do you mean to say that anybody suspects *you?*"

"Everybody does."

"Then you must shew everybody he is a slanderer. Who can have taken the money?"

"There was a pedler who slept in the old barn last night, and — yes, there is possibly Skim, who doesn't bear a very good character."

"Skim, yes; I know him," cried Emily; "he often comes to see father. But it couldn't be Skim. Why, he was with father last night."

All on a sudden the thought struck her of her father's lengthened absence the night before, and of his coming home with gold, too, that she had still about her person. She felt all over her a cold shudder. Where did her father go with Skim?

"Could you identify any of that money, Tom?"

"No; how could I? Sovereigns are sovereigns, as like one another as peas."

"And what will happen to you, Tom, if you don't get the money back?"

"I shall go to prison. Frewen has got a warrant against me already."

"Oh! that's dreadful," said Emily shuddering. "To go to prison like a criminal because you've the misfortune to lose some money! Wait! I hear father; he's just come in. I'll call him."

Collop came in, looking pale and distraught. "Do you know what's happened to Tom?" cried his daughter.

"I've heard something about it," said Collop, shaking his head. — "Oh! Thomas, what would your Aunt Betsy have said if she'd seen you in such a predicament?"

"Tell father how it happened," said Emily.

Tom began the story once more. When he came to speak about hiding the money in the kitchen of the deserted house — for he thought he was safe in being candid with Collop and his daughter — the worthy draper trembled all over, drops of perspiration started from his forehead, and concealed the working of the lower part of his face with his hand. Emily watched them both narrowly, casting quick searching glances at each alternately. But when Tom went

on to speak about the pedler who had lodged in the barn the night before, Collop snatched eagerly at the idea of trying to capture him.

"I'll tell you what, Tom," he said, "I'll help you, I'll offer a reward of five-and-twenty pounds to anybody giving such information as will lead to the capture and conviction of this man. I'll go with you myself to the police-office."

When they reached the police-office, and saw the superintendent, Collop found that it would be quite illegal to offer a reward for the capture "and conviction" of any specified individual. It could only be offered in a general way — for information, that is, leading to the conviction of "the real offenders." Collop cooled down very much at this, and said that he couldn't be a party to bringing people who might be innocent under suspicion. "I don't think it would pay you, sir, to do it," said the superintendent knowingly.

In the interval, time was drawing on, and Tom was doing nothing to avoid the imprisonment that awaited him. "What would you advise me to do?" he asked Collop. "I suppose you couldn't lend me a part of it? Perhaps they'd be satisfied with a part. It's the thought of losing so much money that makes Frewen so bitter against me." Tom looked eagerly at Collop, who pursed up his lips, and shook his head.

"I'll tell you what," whispered Collop in his ear, as they left the police-station and walked slowly towards Collop's shop: "if I were you, I'd cut and run. I daresay you're innocent, but it looks ugly; and, upon my word, Tom, I'd run for it."

Tom looked at Collop in wonder. That such a suggestion should come from the immaculate Collop, struck him with a lively wonder.

"Get away, Tom," went on Collop. "Go to London, and get a situation in another name. I'll — yes, I'll give you a reference, Tom. Send for your wife afterwards. Walk quietly out towards Balderstoke; you can go through my back-yard, and strike into the field-path. There's a train you'll catch at five o'clock, and you'll be in London before they've got scent of your being away."

"I've got no money," muttered Tom ruefully. Assuredly, the thought of London, and employment, and escape from the imprisonment that threatened him, came temptingly upon him. Innocence would be no good to him if he were in prison — his occupation gone, his wife and children starving. They were in a worse plight now than ever, for he had ruined Aunt Booth, who was the only real friend they had. Now, if he got a situation in London, it was a hundred to one if they found him out, and he would be able to keep his own family from the workhouse. And yet to run — to own himself a criminal — to see Tom Rapley wiped out of the book of life, even if destined to reappear under some other designation — no, he couldn't do it, especially as he had no money.

"I'll lend you some," said Collop, replying to Tom's thoughts rather than his words — "a sovereign. Sleep in London to-night, Tom; it's safer."

Tom looked at Collop in amazement. Was this the severe moralist! this the man whom he had regarded as in some uncomfortable way much better than the common run of his fellow-creatures! Was it his advice that coincided so completely with those secret promptings Tom had struggled against as the offspring of his own weakness and cowardice!

Collop didn't trust himself to say anything more to Tom, who started on his homeward walk. As soon as he had gone, he retired into his cave. He passed close by Emily, who was standing in the shop beside a pile of goods, but he did not notice her, and let himself into the little dark counting-house. There sat Skim in the master's chair, quite transformed, in a black velveteen shooting-jacket, with a bright crimson silk handkerchief knotted round his neck, and waistcoat of scarlet plush, with yellow glass buttons, new white corduroy trousers, and Wellington boots.

Collop looked grimly at Skim, as if he would like to kick him out of the place. "Skim," he said, "we made a great blunder last night. It was wrong of us. That money we got out of the old house isn't ours — we've no right to it. I've found out to-day to whom it belongs. It was Tom Rapley's money, that he'd collected for the rates. We must give it back to him, or he'll be sent to prison. I was willing enough to join with you, Skim, as long as I thought we were only finding money that had been hidden long ago and didn't rightly belong to anybody; but this is robbery, downright robbery; and you might be transported for it, Skim. Do you hear? — give back the money."

Skim scorned the proposal, and suggested a further encroachment. "There's more behind, I tell you. We didn't go deep enough. Do you think the old wo-

man would have written falsehoods upon her dying bed? We must go there again to-night. There's thousands there, if we're only bold enough to get it."

Collop's eye glistened at the thought. He forgot all about Tom's misfortunes; he could only dwell upon the golden treasure that might reward their exertions. After a long conference, the two accomplices separated, having given each other a rendezvous for the night.

Meantime, Tom Rapley was making his way homewards, full of trouble and despair, filled with a sort of blind desire to get back to his own house, to pour out his sorrows into the sympathizing bosom of his wife. He avoided the high-road, and made his way by sundry field and bridle paths, till he reached the neighbourhood of Milford's. He had just cleared a young fir-plantation, and come out on the brow of a hill that overlooked the valley of Milford's. The river sparkled beneath him under the rays of the wintry sun; the hills were veiled in a soft, sweet vapour; the gray church tower, the white cottages, the red roof of the manor-house, stood out from the network of leafless trees; a thin canopy of pale blue smoke hovered over the village, throwing out a ribbon of almost impalpable haze that followed the winding course of the stream. Sounds were strangely distinct and clear in the rarefied air. The clink of the blacksmith's hammer, the sound of wheels grating lazily along in a far-off lane, the call of the ploughman to his horses, the rattle of the yoke-chains as they struggled across the broad fallow on the hillside, the impatient bark of a dog in the village, the challenge of chanticleer, and the soft caw of the rooks from that distant turnip-field, fell upon the ear with subdued plaintive resonance. The scene was familiar to Tom, and dear to him; dear, as the scenes of boyhood and youthful scrapes and gambols, and early dreams, and soft, youthful loves. He had thought little of it of late years; absorbed in the carking cares of poverty, he had possessed no eyes for the sweet scenes around him; they had seemed weary and barren to him; but now that he was about to lose all this, to pine within the bare walls of a prison, he began to feel how great a loss he had incurred, and to wonder and regret that he had enjoyed life so little; that groping about among the petty mole-hills of poverty and discontent, he had lost sight of all the fair country that lay behind, free to all who can pluck heart of grace to enjoy it. It was all over now. There was nothing left for him but the thought of what might have been.

Everything seemed so still and tranquil — there was such an atmosphere of content and repose, that Tom found it difficult to realize that this great trouble had really come upon him; that yonder sweet-looking village held for him a budget of unnumbered troubles. But there was one thing that brought him to a lively sense of his present position. On the bridge, where years age the butcher had carried him in his cart across the flood, stood a policeman, and Tom felt in his heart that the man was looking out for him.

He was cut off from home. Tired, hungry, without a penny in his pocket, he had the option of staying here in this damp plantation, or of giving himself up to the law. He felt so utterly helpless and forsaken, that he had made up his mind to do the latter, and bring the matter to an end, when he heard a footstep approaching, and the cheerful note of a song sung by a thin, cracked voice.

"Tom Rapley, ahoy!" sung out the voice joyously. "I was alooking out for you. But don't you come any furder. Back you into that 'ere plantation."

Tom went back into the fir-wood again, where Sailor joined him; and then they left the path, and plunged into the wood till they came to a warm secluded hollow, fragrant with the scent of the turpentine of the firs, and carpeted with the dried spikes that had fallen from their branches. Here they sat down, and Sailor produced a satchel from under his coat, which proved to contain a bottle of ale and a meat pasty. "That was her idea," said Sailor pointing a thumb in the direction of Milford's. "When we found that the bobbies were bustling about, says she: 'Sailor, just you run off, and keep Tom out of danger; he'll come over the hill past Brooks's clump,' says she; and then she packs up this here bit of food, in case as you might'nt have had your dinner. No, no, Master Tom; that's all for you. I had a drop afore I started."

After Tom had eaten and drunk, he felt his courage revive, his mind more capable of facing the troubles before him. Sailor, who had complacently watched the gradual disappearance of the viands, now took his seat on the ground beside Tom. They both lit their pipes, and proceeded to discuss the situation seriously. Lizzie thought, so

Sailor reported, that Tom ought to keep out of the way. There was always the chance that the money might be recovered, and nobody in his senses would submit to be put in prison if he could keep out of it. People said, too, in the village — for a great revulsion of feeling had taken place in favour of Tom, when it was discovered that only his sureties would suffer, and not the parish in general — people said, that perhaps Frewen had gone too far, and might be made to smart for it by-and-by. Frewen had driven over from Biscopham in a furious temper, accompanied by two or three policemen. Tom's house had been searched, but nothing discovered. They didn't even detect the opening into the deserted house. Mrs. Rapley had hung up her gowns so as to conceal the door, and had stood before it all the time the police were there, haranguing them with great vehemence. "It were beautiful to hear her," said Sailor, who had been an eye-witness of the scene, and described it with great gusto. "It were sweet to hear her; she 'bused 'em delightful, sir. There was hardly a name bad enough for 'em, sir; she give 'em their desarts, Master Tom. And the boys hooted old Frewen as he drove through the village."

They were still, however, on the look-out for Tom. It wouldn't be safe to go home till dark, and not even then by the bridge; but there was a punt down at the mill, and Sailor promised to have this ready opposite Milford's, and ferry Tom over. He would land close to the bottom of the garden, and could make his way in the shadowof the tall hedge to the very door of his home; and when he was once there, he could be hidden in the deserted house. There was no chance of the police searching that place, for Frewen had expressly forbidden them, when they proposed to do it, after the domiciliary visit they had paid to the house at the back. "He were quite mad with them, Master Tom," said Sailor, "when they wanted to do it. He wouldn't have the place broken open on no account, and there was no other way of getting in — not that they knew of," added Sailor, with a wink. "It seemed as if he'd got some prime reason why they shouldn't get in there. Do you think he had, Master Tom?"

Tom said he didn't know, but he felt a creepy-crawly sensation down the small of his back when he thought of a lengthened sojourn in that weird deserted house. However, it was better than a prison at all events, and Tom gladly acquiesced in the arrangements that had been made. Sailor left presently, advising Tom to keep in the wood till dusk, and promising to have the punt ready as soon as it was fairly dark.

The night turned out fine, and dark as pitch. Everything went well. Tom was ferried over the river, crept in the shadow of the shrubs to his own door, and was received with open arms by his wife. Sailor came in immediately after. Then the doors were made fast, a curtain pinned securely across the window, the candle lighted, and Lizzie began to prepare supper. Tom was wondering a little what there would be for supper, for there had been nothing in the larder when he left, and he was as much surprised as delighted when the frying-pan began to fizzle on the fire, and a savoury vapour to fill the air with appetizing fragrance.

"We'll have a merry Christmas in spite of everything," said Sailor, "just as I recollect as happened as we was roun'-ing Cape Horn, and ——"

"Hush!" cried Mrs. Tom, holding up her hand — "a footstep."

They all kept breathless silence, and listened intently, as somebody advanced along the pathway with measured tread.

CHAPTER X.

If I had a mind to be honest, I see,
Fortune would not suffer me.

EMILY COLLOP, when she heard Tom's account of the robbery of his money, had felt a shock of sudden fear and shame; and this was intensified, and her suspicion deepened, when she saw Skim enter the shop, looking like a gorgeous-plumaged jail-bird, and carrrying himself with an impudent blustering manner, as if he were the master of everything it contained. Would Skim behave thus in her father's shop if he did not feel that he had some hold upon him? There was no one in the shop, for the boy had gone on an errand, and the shopman had gone home to tea, and Emily glided cautiously to the corner of the shop by the counting-house. There was a crevice between the partition of the counting-house and the wall of the shop, and, by putting an ear to the wall anything that was said within could be distinctly heard. Emily had acquired a knowledge of this when she was a girl, but she had made no use of it for many years, being far too honourably minded a girl to pry into her father's concerns. In this case, however,

she felt justified. She might be the means of saving both her father and Tom from the consequences of some cruel, wicked deed. What she first heard, enlightened and relieved her mind a good deal. Her father had not intended to rob Tom Rapley — that was evident. He had stumbled upon the money in the search for something else. But, at the same time, it was equally clear that they had got Tom's money, and no doubt, now that he had found out the mistake, her father would insist on Skim's disgorging his share of the plunder.

The final result of the interview astounded her. They were not going to do justice to Tom. He was to be left to his fate, whilst the two conspirators enjoyed the fruits of their robbery. And this was her father! The moment was one of supreme and bitter anguish. Then she remembered that she too was a participator in the crime. She carried abont on her person a share of the ill-gotten plunder.

On this one point her course was clear enough. She must at once get rid of the guilty burden she carried, and in a way that might lift the suspicion from Tom. At the same time, her father's safety must not be jeopardized. She would do this now at once, before her father had a chance of getting the money from her.

She took the bag of gold, and hastily wrapped it in a piece of brown paper — first putting inside a slip of paper, on which she had written: "Restoration from the man who robbed Tom Rapley."

Then she addressed the parcel to the superintendent of police, and putting on an old waterproof cloak, and a thick Shetland veil, which concealed her features completely, she set out for the police-office. There was no one about when she reached the place, and she made her way to the superintendent's office unchallenged. That was empty too. She left the parcel upon his desk, and hurried away. When she reached home, she found that her father had been searching for her everywhere, and was very angry at her absence.

"Emily," he said, "I want some of that money. Ten pounds or so. Give it me."

"I haven't got it, father," she said: "I have restored it to the rightful owner!"

Collop turned quite livid with rage and fear. "What do you mean, girl? Have you stolen it, you thief?"

"It is not I who am the thief, father!" cried Emily, confronting him with blazing eyes.

Collop quailed under her glance. He sank into a chair, laid his head upon the table, and groaned. "Then you have betrayed your father, girl?" he muttered.

"No; I haven't betrayed you, father," said Emily; "and I won't! But you must tell me everything; and every penny you have got of Tom's you must refund, and make that villain Skim also."

"I can't, I tell you, Emily. I had paid away a hundred and fifty pounds before I had heard of that fool's ill-luck. I should have had the bailiffs in the house if I hadn't."

Emily burst into tears. "How could you, father!" she sobbed.

"Look here!" cried Collop. "Emmy, if what I have on hand succeeds, I shall have abundance of money to pay Tom back again, and reward him handsomely for what he may have suffered."

"O wild, silly schemes!" cried Emily; "digging for buried treasure that has no existence except in the muddled wits of a tipsy labourer. Father, has it come to this?"

"I tell you, Emmy, it is not a wild or silly scheme. The man is right. The old woman had lots of ready-money! She was constantly coming to me for gold. Why, the very day before she died, she carried home in her chaise five hundred pounds in gold. She always got it through me, and I was glad to oblige her, as it gave me some credit with my bankers to have the handling of so much money. No mention was made of that in her will. Why, I saw the schedule of her effects for probate, and excepting two pounds five in her purse at her death, there wasn't a penny of ready-money. Now, where is it?"

"How is it possible to tell?"

"I tell you, Emily, it's there somewhere! Why, the very last time I saw her — you know how fond she was of picking out a text and expounding upon it. Well, she'd got hold of this: 'Lay not up for yourselves treasures upon earth;' and there was a sort of tone about her when she said upon earth, that I felt sure she was thinking how clever she was to have got round a text like that. Now, if she'd buried her money, don't you see it didn't apply — because it was under the earth!"

"O, father, Aunt Betsy was never so silly as all that."

"You didn't know her as I did, child.

When she was about business, she was as keen a hand as ever you met; but get her on spiritual matters, and she was wild enough. She thought that she'd found out that there was to be another deluge; and more than once she's said to me: 'James, don't you think that in the new world it will be better for those who have saved and laid by money?' And I said to her: 'You can't carry your money with you.'—'No; but, James,' she said, 'one might come back to it.'—Oh! I knew she'd some scheme of the kind working in her mind."

"But, father, granting that you are right—even if there is money there—it doesn't belong to you."

"To me as much, nay, more than any one else. Didn't she always call me her brother? Didn't she promise me continually, that if she were removed first, she would take care that I should be left comfortable? Wasn't it to please her that I began, first to neglect my business a little, and take to mooning after those false prophets? Didn't I work for her and for her schemes for years without ever getting a penny from her—paid with promises, lured on with fair words? And now you tell me I have no claim upon this money, if I find it!"

"I don't think you have, father."

"Don't tell me!" said Collop. "Why, for the last year I have kept that man Skim in my employ, and he has spent night after night in digging and delving; and just as we have got the clue, and see success before us, I am to hand the treasure over to Mr. Frewen, I suppose!"

"I didn't say that, father."

"I am to go to Mr. Frewen," cried Collop, who had been working himself gradually into a passion; "and I am to say to him: 'Good sir, you have been my enemy all my life; you have brought me to the threshold of disgrace and destitution; you have preyed upon my vitals, and drained me of every hard-earned penny; and in return for this, here's untold gold—gold I have found, and kept for you: and now, send me to the workhouse, or the jail, good, kind sir!'"

"Father, you frighten me!" cried Emily.

"I tell you, girl!" he cried, almost foaming at the mouth, "sooner than this, I'd kill him! yes, kill him! and you too, false girl, if you betray me!"

Nothing she had ever known of her father had prepared her for this ebullition of rage and passion.

"Don't threaten me, father," she said, silently weeping; "don't talk to me like that, and I'll be true to you through everything. I'm in the same ship with you, and I can't help taking your part; only don't rob poor Tom!"

Mr. Frewen and the superintendent of police came back to Biscopham together at about nine o'clock that evening, the former in a very bad temper. They drove up to the police-station, and Frewen accompanied the superintendent into his office, to see if anything had transpired about Tom. There was the package of money. The superintendent opened it, looked at the slip of paper, and handed it to Mr. Frewen.

"Eh! Brown, what does that mean?" cried the latter, looking sharply up from under his shaggy eyebrows. The police-officer, meantime, had been carefully examining the brown paper in which the money had been wrapped.

"It smells of fustian," said the man, laughing.

"What do you mean?"

"It comes from Collop's shop; he was there to-day, for an hour or two."

"But the money, the gold, that's right enough, it seems; why should they send back any of it?"

"You've frightened 'em, sir, by being so determined. And more can be got yet."

"Upon my word, I think you re right," cried Frewen: "we'll drive over to Milford once more, and surprise 'em. But we won't knock up either your horse or mine; we'll send to the *White Lion* for a machine of some sort."

The worthy host of the *White Lion* threw up his hands in amazement, when the order for the carriage came in. "Trap to go to Milford! Why, they're all going to Milford. There's a regular gathering of 'em over there. What's up, I wonder?"

CHAPTER XI.

Who finds her, give her burying.
. . . . . .
Beside this treasure for a fee,
The gods requite his charity.

AT the sound of the heavy tread coming up the footpath, all the inmates of the little back-kitchen turned pale. Lizzie rose and opened the door that led up to their bedroom, and pointed to Tom to go. "Get into the old house," she whispered as he passed her, "and I'll take care they don't follow you."

Tom went softly up-stairs, and passed

from the bed-room into his little office. Lizzie followed him, and hung up some dresses over the cracks of the door, shutting out every gleam of light. He staid a long time in the dark whilst a conversation was going on down-stairs. Then Lizzie came up with a light and opened the door.

"It *was* a policeman," she said, "wanted to know whether you had come home. 'No,' says I. 'And what was those voices?' says he. And then Sailor steps out — he hadn't seen him before: 'What, ain't it allowed for people to talk to one another in this free country without a bobby listening!' and then he got cross, and said he'd come in and see whether you was here. 'No,' says I, 'you don't; not without a warrant,' says I. 'Oh, well,' he said, 'he'd soon fetch that;' and away he goes. But they'll be here again, sure enough. They're regular down upon you, Tom."

"It's a burning shame," said Tom. "They won't help a poor fellow who's been robbed, and make all sorts of game of him; and they're regular slaves to Frewen, because he's one of the big-wigs. It ain't justice, Lizzie."

"Well, Tom, what we've got to do is to slip our necks out of the noose. They'll be back again directly, Tom; and we must make up this door somehow, so that it shan't look as if it were a door at all. Look here, Tom; take a couple of blankets. You should have the bed, too, only that would be noticed."

"What! ain't I to sleep in my own bed?" said Tom, ruefully regarding the nuptial couch.

"No, indeed, Tom; you can't. We must make up the door, and you must be on the other side of it. Then take the candle. No, goodness, Tom; you mustn't have that. I forgot; it would betray all."

"What! stop here all in the dark?" remonstrated Tom.

"Why, yes, old man. The least shine of a light through a chink outside would ruin everything. Now, go, Tom — do — directly, please."

"Well, if I was in prison," muttered Tom, "I should have a light, and a bed to sleep on too, perhaps. If it wasn't for the name of the thing, I'd be better off there."

Lizzie shut the door upon his remonstrances, and presently hammer and nails were at work on the other side closing up the door.

"It's for all the world as if they were putting me in my coffin," said Tom, with a shudder.

Another last word, through a slit in the boards: "Tom, you mustn't stop there: they will hear you cough, or sneeze, or walk on the boards. Go down into the kitchen."

With hands stretched out before him blindly groping his way through the thick darkness, Tom, in fear and trembling, felt his way along the passage and down the staircase of the deserted house. He knew the way well, but once or twice he stumbled where a board had sprung, or a lump of plaster had fallen from the ceiling; and, stretching out his hands to save himself, he would shudder at the cold, clammy touch of the wall. How the stairs creaked and groaned as he descended! they seemed to shriek almost, as if they were given warning of his whereabouts to people outside. He reached the kitchen at last, and stood in the middle of the floor, and wondered what he should do next. He shuddered at the thought of lying down here amongst all these crawling loathsome insects; yet he couldn't stand up all night shivering and shaking. The night had turned very cold; there was a hard frost; it seemed he could see a bright star twinkling through a crevice where the new brick-work in the window had settled. It would not do to have a light, certainly. The shine of it would be as discernible to any one outside as the glimmer of the star to him within.

As soon as he became perfectly quiet, and the beating of the pulse in his ear ceased to overpower all other sounds, he heard a noise that made his flesh creep upon his bones. The sound itself, indeed, was not appalling — a comfortable, home-like, domestic sound; it was the circumstances under which he heard it that made it so terrific. Here, in this deserted, abandoned house, given over to solitude and silence for all these years — in this house, so hermetically closed and sealed against the outside world, the clock was ticking loudly!

Clink, clank, with a resonant, cavernous voice, the old clock was agoing; who could have started it? Tom shivered and shuddered, as in the presence of some new indefinite peril. Who could have set that clock agoing? In Aunt Betsy's time, no hand but hers was ever permitted to touch that sacred clock. At nine o'clock every Saturday night, the clock was wound up, just before Aunt Betsy went to bed. This was Sat-

urday night, and just after nine. Had Aunt Betsy arisen this cold winter's night, and come to wind up the clock? Tom fancied that something brushed past him, that his hand touched something cold: he could have shouted with terror; he would have run, regardless of all risks, back to his own room, but he felt chained and rooted to the spot. He felt, with his foot, around him, not daring to stir from the place; and his foot came in contact with something that rattled as he struck it. It was a box of lucifer-matches.

Tom didn't think of how the matches got there, or of the danger of striking a light. He was only conscious of an eager desire to dissipate the terrors that surrounded him. He picked up the match-box and struck a light. As the flame leaped into life, there was a gentle rustle and stir about him: beetles, cock-roaches, crickets, made a general stampede. If any other forms had lurked in the darkness, they had softly disappeared. The old clock, whose face was in strong contrast to the general dirt and griminess of the place, was placidly ticking away through it all: At his feet there lay a piece of wax-candle.

"There have been thieves here, the thieves who stole my money," said Tom to himself. "Surely, if the police saw this, they would believe me; but then there's nothing here but what I could have put myself, so I should be no better off."

Then Tom became alive to the danger he incurred of discovery. He blew out his light, and began to ponder as to what he should do next. His meditations were interrupted by a low noise of grating and grinding, that came from the direction of the hall-door, and Tom thought that he heard whispered conversation as well. The sounds grew more and more distinct; clearly some persons were trying to get into the house from outside. The police, no doubt, thought Tom; they have caught sight of the light, and they mean to hem me in on all sides. To retreat by the way he came, Tom saw, would be to put his head into the lion's mouth. They had possession of the house by this time, no doubt, and his capture would only be a question of time. But there was one chance: the cellar that ran under the old part of the house, the entrance to which was from the inner corner of the kitchen, the door being close to the clock. Guided by the ticking of the clock, Tom made his way to the cellar door, which was unfastened. When Tom got to the bottom of the cellar stairs, he found himself in a warmer and softer atmosphere — an atmosphere strangely perfumed, too, with the fragrance of drugs and spices. There was no damp or chilliness about these cellars, which had been made centuries ago. Warm in winter, and cool in summer, they had been splendid wine-cellars in the olden days. Many a pipe of good old port, many a cask of sherry, and butt of generous Madeira, had been drained dry in that famous cellar in days long gone by.

The sounds from the hall-door had ceased. Tom began to think that he had been deceived, and that the noise he had heard had simply been the wind, that was now beginning to rise, and sough mournfully around. But he had much bettered his position, as he would be far warmer and more comfortable down here than in that dismal kitchen. Everything was quiet above, and he thought he might venture to strike a light, that he might reconnoitre his position, and make himself snug for the night, for he began to feel insupportably weary. The one window in the cellar opened into the garden, and was so overgrown outside with rank vegetation, that there was no danger of his light being seen, even if it had not been properly blocked up.

The candle lighted, Tom looked around him. The cellar seemed altogether clean and bare, just as he remembered it of old. A ledge or table ran all round it, topped with a stone slab, which had formerly held dishes and pans. There was the old cask-stand in one corner; and in the other, there was something new and strange — something that struck Tom with an instinctive terror and dread.

In form and general appearance, this was like a sentry-box, and of the same height and size; but it was shaped at the ends so as also to resemble a boat set on end. Round the edge was a broad border of cork, painted black, so that, if a boat at all, it must be a life-boat. It was inclosed in front with a lid door or deck of polished oak. At the top of this was a narrow grating of brass or gilt metal. A small brass knob, half-way down, indicated that here was the way of opening the lid or deck. Something was tied to this knob by a piece of string, in appearance and reality a letter. Curiosity outmastered fear. Tom advanced and snatched the letter from the knob. It was in Aunt Betsy's handwriting, sealed

with her great gold seal, and addressed simply to "My Successor."

Tom opened the letter full of strange awe. Yes, it was from Aunt Betsy — a posthumous message from his aunt:

When you, young sir, open this — if you ever do open it, as I hope and sincerely trust you never may — all my hopes will have come to an end, and you may smile at the folly of an old woman who has trusted to lying promises. Laugh yourself, if you will, but do not let any one else laugh. To you, at all events, I have proved a benefactor. Respect my memory and my wishes. My wishes are: that this house be pulled down, and every trace of it destroyed; that my poor body be put in a coffin, with quicklime, and buried quietly in the churchyard of Milford, with a marble monument, and the figure of a shipwreck over it, and that the epitaph upon it shall be: "Here lies poor Betsy Rennel. She was born before her time, lived after her prime, and lies here in' lime." To pay these expenses, and to reward you for executing my wishes, I will give you this rhyme:

Underneath the thyme and mint, the marjoram and the rue,
Dig deep, and you shall find a herb that's safe to pleasure you.

If you can't understand this, you are a fool, and may lose your thousands.

BETSY RENNEL.

"Well, I *am* a fool, then," cried Tom, "for I don't understand a single word of it all. Then this is waiting for the young squire that is to be. And what's inside here, I wonder? Fancy Aunt Betsy writing that kind of stuff! Why, she ought to have been in Bedlam; an old ——"

Here Tom paused, and his tongue cleaved to the roof of his mouth, for the lid of the box had swung slowly open, and there was old Aunt Betsy standing right before him!

He gave a wild cry of horror and despair, and sank helpless and senseless on the floor.

From Nature.

INAUGURAL ADDRESS OF PROF. JOHN TYNDALL, D.C.L., LL.D., F.R.S., PRESIDENT.

AN impulse inherent in primeval man turned his thoughts and questionings betimes towards the sources of natural phenomena. The same impulse, inherited and intensified, is the spur of scientific action to-day. Determined by it, by a process of abstraction from experience we form physical theories which lie beyond the pale of experience, but which satisfy the desire of the mind to see every natural occurrence resting upon a cause. In forming their notions of the origin of things, our earliest historic (and doubtless, we might add, our prehistoric) ancestors pursued, as far as their intelligence permitted, the same course. They also fell back upon experience, but with this difference — that the particular experiences which furnished the weft and woof of their theories were drawn, not from the study of nature, but from what lay much closer to them, the observation of men. Their theories accordingly took an anthropomorphic form. To supersensual beings, which, "however potent and invisible, were nothing but a species of human creatures, perhaps raised from among mankind, and retaining all human passions and appetites,"* were handed over the rule and governance of natural phenomena.

Tested by observation and reflection, these early notions failed in the long run to satisfy the more penetrating intellect of our race. Far in the depths of history we find men of exceptional power differentiating themselves from the crowd, rejecting these anthropomorphic notions, and seeking to connect natural phenomena with their physical principles. But long prior to these purer efforts of the understanding the merchant had been abroad, and rendered the philosopher possible; commerce had been developed, wealth amassed, leisure for travel and for speculation secured, while races educated under different conditions, and therefore differently informed and endowed, had been stimulated and sharpened by mutual contact. In those regions where the commercial aristocracy of ancient Greece mingled with its eastern neighbours, the sciences were born, being nurtured and developed by free-thinking and courageous men. The state of things to be displaced may be gathered from a passage of Euripides quoted by Hume. "There is nothing in the world; no glory, no prosperity. The gods toss all into confusion; mix everything with its reverse, that all of us, from our ignorance and uncertainty, may pay them the more wor-

* Hume, "Natural History of Religion."

ship and reverence." Now, as science demands the radical extirpation of caprice and the absolute reliance upon law in nature, there grew with the growth of scientific notions a desire and determination to sweep from the field of theory this mob of gods and demons, and to place natural phenomena on a basis more congruent with themselves.

The problem which had been previously approached from above was now attacked from below; theoretic effort passed from the super to the sub-sensible. It was felt that to construct the universe in idea it was necessary to have some notion of its constituent parts — of what Lucretius subsequently called the "First Beginnings." Abstracting again from experience, the leaders of scientific speculation reached at length the pregnant doctrine of atoms and molecules, the latest developments of which were set forth with such power and clearness at the last meeting of the British Association. Thought no doubt had long hovered about this doctrine before it attained the precision and completeness which it assumed in the mind of Democritus,* a philosopher who may well for a moment arrest our attention. "Few great men," says Lange, in his excellent "History of Materialism," a work to the spirit and the letter of which I am equally indebted, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of the 'laughing philosopher,' while figures of immeasurably smaller significance spread themselves at full length before us." Lange speaks of Bacon's high appreciation of Democritus — for ample illustrations of which I am indebted to my excellent friend Mr. Spedding, the learned editor and biographer of Bacon. It is evident, indeed, that Bacon considered Democritus to be a man of weightier metal than either Plato or Aristotle, though their philosophy "was noised and celebrated in the schools amid the din and pomp of professors." It was not they, but Genseric and Attila and the barbarians, who destroyed the atomic philosophy. "For at a time when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and came down to us, while things more solid sank and almost passed into oblivion."

* Born 460 B.C.

The principles enunciated by Democritus reveal his uncompromising antagonism to those who deduced the phenomena of nature from the caprices of the gods. They are briefly these: — 1. From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. 2. Nothing happens by chance. Every occurrence has its cause from which it follows by necessity. 3. The only existing things are the atoms and empty space; all else is mere opinion. 4. The atoms are infinite in number, and infinitely various in form; they strike together, and the lateral motions and whirlings which thus arise are the beginnings of worlds. 5. The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation. 6. The soul consists of free, smooth, round atoms, like those of fire. These are the most mobile of all. They interpenetrate the whole body, and in their motions the phenomena of life arise. Thus the atoms of Democritus are individually without sensation; they combine in obedience to mechanical laws; and not only organic forms, but the phenomena of sensation and thought are also the result of their combination.

That great enigma, "the exquisite adaptation of one part of an organism to another part, and to the conditions of life," more especially the construction of the human body, Democritus made no attempt to solve. Empedocles, a man of more fiery and poetic nature, introduced the notion of love and hate among the atoms to account for their combination and separation. Noticing this gap in the doctrine of Democritus, he struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus more than 2,000 years ago, the doctrine of the "survival of the fittest," which in our day, not on the basis of vague conjecture, but of positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation.*

Epicurus,† said to be the son of a poor schoolmaster at Samos, is the next com-

* Lange, 2nd edit., p. 23.
† Born 342 B.C.

inant figure in the history of the atomic philosophy. He mastered the writings of Democritus, heard lectures in Athens, returned to Samos, and subsequently wandered through various countries. He finally returned to Athens, where he bought a garden, and surrounded himself by pupils, in the midst of whom he lived a pure and serene life, and died a peaceful death. His philosophy was almost identical with that of Democritus; but he never quoted either friend or foe. One main object of Epicurus was to free the world from superstition and the fear of death. Death he treated with indifference. It merely robs us of sensation. As long as we are, death is not; and when death is, we are not. Life has no more evil for him who has made up his mind that it is no evil not to live. He adored the gods, but not in the ordinary fashion. The idea of divine power, properly purified, he thought an elevating one. Still he taught, "Not he is godless who rejects the gods of the crowd, but rather he who accepts them." The gods were to him eternal and immortal beings, whose blessedness excluded every thought of care or occupation of any kind. Nature pursues her course in accordance with everlasting laws, the gods never interfering. They haunt

> The lucid interspace of world and world
> Where never creeps a cloud or moves a wind,
> Nor ever falls the least white star of snow,
> Nor ever lowest roll of thunder moans,
> Nor sound of human sorrow mounts to mar
> Their sacred everlasting calm.*

Lange considers the relation of Epicurus to the gods subjective; the indication probably of an ethical requirement of his own nature. We cannot read history with open eyes, or study human nature to its depths, and fail to discern such a requirement. Man never has been and he never will be satisfied with the operations and products of the understanding alone; hence physical science cannot cover all the demands of his nature. But the history of the efforts made to satisfy these demands might be broadly described as a history of errors — the error consisting in ascribing fixity to that which is fluent, which varies as we vary, being gross when we are gross, and becoming, as our capacities widen, more abstract and sublime. On one great point the mind of Epicurus was at peace. He neither sought nor expected, here or hereafter, any personal profit from his relation to the gods. And it is assuredly a fact that loftiness and serenity of thought may be promoted by conceptions which involve no idea of profit of this kind. "Did I not believe," said a great man to me once, "that an Intelligence is at the heart of things, my life on earth would be intolerable." The utterer of these words is not, in my opinion, rendered less noble but more noble, by the fact that it was the need of ethical harmony here, and not the thought of personal profit hereafter, that prompted his observation.

A century and a half after the death of Epicurus, Lucretius* wrote his great poem, "On the Nature of Things," in which he, a Roman, developed with extraordinary ardour the philosophy of his Greek predecessor. He wishes to win over his friend Memnius to the school of Epicurus; and although he has no rewards in a future life to offer, although his object appears to be a purely negative one, he addresses his friend with the heat of an apostle. His object, like that of his great forerunner, is the destruction of superstition; and considering that men trembled before every natural event as a direct monition from the gods, and that everlasting torture was also in prospect, the freedom aimed at by Lucretius might perhaps be deemed a positive good. "This terror," he says, "and darkness of mind must be dispelled, not by the rays of the sun and glittering shafts of day, but by the aspect and the law of nature." He refutes the notion that anything can come out of nothing, or that that which is once begotten can be recalled to nothing. The first beginnings, the atoms, are indestructible, and into them all things can be dissolved at last. Bodies are partly atoms and partly combinations of atoms; but the atoms nothing can quench. They are strong in solid singleness, and by their denser combination all things can be closely packed and exhibit enduring strength. He denies that matter is infinitely divisible. We come at length to the atoms, without which, as an imperishable substratum, all order in the generation and development of things would be destroyed.

The mechanical shock of the atoms being in his view the all-sufficient cause of things, he combats the notion that the constitution of nature has been in any way determined by intelligent design. The interaction of the atoms throughout

* Tennyson's "Lucretius."

* Born 99 B.C.

infinite time rendered all manner of combinations possible. Of these the fit ones persisted, while the unfit ones disappeared. Not after sage deliberation did the atoms station themselves in their right places, nor did they bargain what motions they should assume. From all eternity they have been driven together, and after trying motions and unmotions of every kind, they fell at length into the arrangements out of which this system of things has been formed. His grand conception of the atoms falling silently through immeasurable ranges of space and time suggested the nebular hypothesis to Kant, its first propounder. "If you will apprehend and keep in mind these things, Nature, free at once, and rid of her haughty lords, is seen to do all things spontaneously of herself, without the meddling of the gods." *

During the centuries between the first of these three philosophers and the last, the human intellect was active in other fields than theirs. The Sophists had run through their career. At Athens had appeared the three men, Socrates, Plato, and Aristotle, whose yoke remains to some extent unbroken to the present hour. Within this period also the School of Alexandria was founded, Euclid wrote his "Elements," and he and others made some advance in optics. Archimedes had propounded the theory of the lever and the principles of hydrostatics. Pythagoras had made his experiments on the harmonic intervals, while astronomy was immensely enriched by the discoveries of Hipparchus, who was followed by the historically more celebrated Ptolemy. Anatomy had been made the basis of scientific medicine; and it is said by Draper † that vivisection then began. In fact, the science of ancient Greece had already cleared the world of the fantastic images of divinities operating capriciously through natural phenomena. It had shaken itself free from that fruitless scrutiny "by the internal light of the mind alone," which had vainly sought to transcend experience and reach a knowledge of ultimate causes. Instead of accidental observation, it had introduced observation with a purpose; instruments were employed to aid the senses; and scientific method was rendered in a great measure complete by the union of induction and experiment.

What, then, stopped its victorious advance? Why was the scientific intellect compelled, like an exhausted soil, to lie fallow for nearly two millenniums before it could regather the elements necessary to its fertility and strength? Bacon has already let us know one cause; Whewell ascribes this stationary period to four causes — obscurity of thought, servility, intolerance of disposition, enthusiasm of temper; and he gives striking examples of each.* But these characteristics must have had their causes, which lay in the circumstances of the time. Rome and the other cities of the empire had fallen into moral putrefaction. Christianity had appeared offering the gospel to the poor, and by moderation if not asceticism of life, practically protesting against the profligacy of the age. The sufferings of the early Christians and the extraordinary exaltation of mind which enabled them to triumph over the diabolical tortures to which they were subjected,† must have left traces not easily effaced. They scorned the earth, in view of that "building of God, that house not made with hands, eternal in the heavens." The Scriptures which ministered to their spiritual needs were also the measure of their science. When, for example, the celebrated question of antipodes came to be discussed, the Bible was with many the ultimate court of appeal. Augustine, who flourished A.D. 400, would not deny the rotundity of the earth, but he would deny the possible existence of inhabitants at the other side, "because no such race is recorded in Scripture among the descendants of Adam." Archbishop Boniface was shocked at the assumption of a "world of human beings out of the reach of the means of salvation." Thus reined in, science was not likely to make much progress. Later on, the political and theological strife between the Church and civil goverments, so powerfully depicted by Draper, must have done much to stifle investigation.

Whewell makes many wise and brave remarks regarding the spirit of the Middle Ages. It was a menial spirit. The seekers after natural knowledge had forsaken that fountain of living waters, the direct appeal to nature by observation and experiment, and had given themselves up to the remanipulation of the

* Monro's translation. In his criticism of this work (*Contemporary Review*, 1867) Dr. Hayman does not appear to be aware of the really sound and subtle observations on which the reasoning of Lucretius, though erroneous, sometimes rests.

† "History of the Intellectual Development of Europe," p. 295.

* "History of the Inductive Sciences," vol. i.

† Depicted with terrible vividness in Rénan's "Antichrist."

notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral causes, while an exercise of the phantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation. Then came the Mysticism of the Middle Ages, magic, alchemy, the Neo-platonic philosophy, with its visionary though sublime attractions, which caused men to look with shame upon their own bodies as hindrances to the absorption of the creature in the blessedness of the Creator. Finally came the scholastic philosophy, a fusion, according to Lange, of the least mature notions of Aristotle with the Christianity of the west. Intellectual immobility was the result. As a traveller without a compass in a fog may wander long, imagining he is making way, and find himself, after hours of toil, at his starting-point, so the schoolmen, having tied and untied the same knots, and formed and dissipated the same clouds, found themselves at the end of centuries in their old position.

With regard to the influence wielded by Aristotle in the Middle Ages, and which, though to a less extent, he still wields, I would ask permission to make one remark. When the human mind has achieved greatness and given evidence of extraordinary power in any domain, there is a tendency to credit it with similar power in all other domains. Thus theologians have found comfort and assurance in the thought that Newton dealt with the question of revelation, forgetful of the fact that the very devotion of his powers, through all the best years of his life, to a totally different class of ideas, not to speak of any natural disqualification, tended to render him less instead of more competent to deal with theological and historic questions. Goethe, starting from his established greatness as a poet, and indeed from his positive discoveries in natural history, produced a profound impression among the painters of Germany when he published his "Farbenlehre," in which he endeavoured to overthrow Newton's theory of colours. This theory he deemed so obviously absurd, that he considered its author a charlatan, and attacked him with a corresponding vehemence of language. In the domain of natural history Goethe had made really considerable discoveries; and we have high authority for assuming that had he devoted himself wholly to that side of science, he might have reached in it an eminence comparable with that which he attained as a poet. In sharpness of observation, in the detection of analogies however apparently remote, in the classification and organization of facts according to the analogies discerned, Goethe possessed extraordinary powers. These elements of scientific inquiry fall in with the discipline of the poet. But, on the other hand, a mind thus richly endowed in the direction of natural history, may be almost shorn of endowment as regards the more strictly called physical and mechanical sciences. Goethe was in this condition. He could not formulate distinct mechanical conceptions; he could not see the force of mechanical reasoning; and in regions where such reasoning reigns supreme he became a mere *ignis fatuus* to those who followed him.

I have sometimes permitted myself to compare Aristotle with Goethe, to credit the Stagirite with an almost superhuman power of amassing and systematizing facts, but to consider him fatally defective on that side of the mind in respect to which incompleteness has been justly ascribed to Goethe. Whewell refers the errors of Aristotle, not to a neglect of facts, but to "a neglect of the idea appropriate to the facts, the idea of mechanical cause, which is force, and the substitution of vague or inapplicable notions, involving only relations of space or emotions of wonder." This is doubtless true; but the word "neglect" implies mere intellectual misdirection, whereas in Aristotle, as in Goethe, it was not, I believe, misdirection, but sheer natural incapacity which lay at the root of his mistakes. As a physicist, Aristotle displayed what we should consider some of the worst attributes of a modern physical investigator — indistinctness of ideas, confusion of mind, and a confident use of language, which led to the delusive notion that he had really mastered his subject, while he as yet had failed to grasp even the elements of it. He put words in the place of things, subject in the place of object. He preached induction without practising it, inverting the true order of inquiry by passing from the general to the particular, instead of from the particular to the general. He made of the universe a closed sphere, in the centre of which he fixed the earth, proving from general principles, to his own satisfaction and that of the world for near

2,000 years, that no other universe was possible. His notions of motion were entirely unphysical. It was natural or unnatural, better or worse, calm or violent — no real mechanical conception regarding it lying at the bottom of his mind. He affirmed that a vacuum could not exist, and proved that if it did exist motion in it would be impossible. He determined *à priori* how many species of animals must exist, and showed on general principles why animals must have such and such parts. When an eminent contemporary philosopher, who is far removed from errors of this kind, remembers these abuses of the *à priori* method, he will be able to make allowance for the jealousy of physicists as to the acceptance of so-called *à priori* truths. Aristotle's errors of detail were grave and numerous. He affirmed that only in man we had the beating of the heart, that the left side of the body was colder than the right, that men have more teeth than women, and that there is an empty space, not at the front, but at the back of every man's head.

There is one essential quality in physical conceptions which was entirely wanting in those of Aristotle and his followers. I wish it could be expressed by a word untainted by its associations; it signifies a capability of being placed as a coherent picture before the mind. The Germans express the act of picturing by the word *vorstellen*, and the picture they call a *vorstellung*. We have no word in English which comes nearer to our requirements than *imagination*, and, taken with its proper limitations, the word answers very well; but, as just intimated, it is tainted by its associations, and therefore objectionable to some minds. Compare, with reference to this capacity of mental presentation, the case of the Aristotelian, who refers the ascent of water in a pump to Nature's abhorrence of a vacuum, with that of Pascal when he proposed to solve the question of atmospheric pressure by the ascent of the Puy de Dome. In the one case the terms of the explanation refuse to fall into place as a physical image; in the other the image is distinct, the fall and rise of the barometer being clearly figured as the balancing of two varying and opposing pressures.

During the drought of the Middle Ages in Christendom, the Arabian intellect, as forcibly shown by Draper, was active. With the intrusion of the Moors into Spain, cleanliness, order, learning, and refinement took the place of their opposites. When smitten with the disease, the Christian peasant resorted to a shrine; the Moorish one to an instructed physician. The Arabs encouraged translations from the Greek philosophers, but not from the Greek poets. They turned in disgust "from the lewdness of our classical mythology, and denounced as an unpardonable blasphemy all connection between the impure Olympian Jove and the Most High God." Draper traces still further than Whewell the Arab element in our scientific terms, and points out that the under garment of ladies retains to this hour its Arab name. He gives examples of what Arabian men of science accomplished, dwelling particularly on Alhazen, who was the first to correct the Platonic notion that rays of light are emitted by the eye. He discovered atmospheric refraction, and points out that we see the sun and moon after they have set. He explains the enlargement of the sun and moon, and the shortening of the vertical diameters of both these bodies, when near the horizon. He is aware that the atmosphere decreases in density with increase of height, and actually fixes its height at 58 1-2 miles. In the Book of the Balance Wisdom, he sets forth the connection between the weight of the atmosphere and its increasing density. He shows that a body will weigh differently in a rare and a dense atmosphere: he considers the force with which plunged bodies rise through heavier media. He understands the doctrine of the centre of gravity, and applies it to the investigation of balances and steelyards. He recognizes gravity as a force, though he falls into the error of making it diminish as the distance, and of making it purely terrestrial. He knows the relation between the velocities, spaces, and times of falling bodies, and has distinct ideas of capillary attraction. He improves the hydrometer. The determination of the densities of the bodies as given by Alhazen approach very closely to our own. "I join," says Draper, in the pious prayer of Alhazen, "that in the day of judgment the All-Merciful will take pity on the soul of Abur Raihân, because he was the first of the race of men to construct a table of specific gravities." If all this be historic truth (and I have entire confidence in Dr. Draper), well may he "deplore the systematic manner in which the literature of Europe has contrived to put out of sight our scientific obligations to the Mahomedans." *

* "Intellectual Development of Europe," p. 359.

Towards the close of the stationary period a word-weariness, if I may so express it, took more and more possession of men's minds. Christendom had become sick of the school philosophy and its verbal wastes, which led to no issue, but left the intellect in everlasting haze. Here and there was heard the voice of one impatiently crying in the wilderness, "Not unto Aristotle, not unto subtle hypotheses, not unto Church, Bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of nature by observation and experiment." In 1543 the epoch-making work of Copernicus on the paths of the heavenly bodies appeared. The total crash of Aristotle's closed universe with the earth at its centre followed as a consequence; and "the earth moves" became a kind of watchword among intellectual freemen. Copernicus was the Canon of the Church of Frauenburg, in the diocese of Ermeland. For three-and-thirty years he had withdrawn himself from the world and devoted himself to the consolidation of his great scheme of the solar system. He made its blocks eternal; and even to those who feared it and desired its overthrow it was so obviously strong that they refrained from meddling with it. In the last year of the life of Copernicus his book appeared: it is said that the old man received a copy of it a few days before his death, and then departed in peace.

The Italian philosopher Giordano Bruno was one of the earliest converts to the new astronomy. Taking Lucretius as his exemplar, he revived the notion of the infinity of worlds; and combining with it the doctrine of Copernicus, reached the sublime generalization that the fixed stars are suns, scattered numberless through space and accompanied by satellites, which bear the same relation to them as the earth does to our sun, or our moon to our earth. This was an expansion of transcendent import; but Bruno came closer than this to our present line of thought. Struck with the problem of the generation and maintenance of organisms, and duly pondering it, he came to the conclusion that nature in her productions does not imitate the technic of man. Her process is one of unravelling and unfolding. The infinity of forms under which matter appears were not imposed upon it by an external artificer; by its own intrinsic force and virtue it brings these forms forth. Matter is not the mere naked, empty *capacity* which philosophers have pictured her to be, but the universal mother, who brings forth all things as the fruit of her own womb.

This outspoken man was originally a Dominican monk. He was accused of heresy and had to fly, seeking refuge in Geneva, Paris, England, and Germany. In 1592 he fell into the hands of the Inquisition at Venice. He was imprisoned for many years, tried, degraded, excommunicated, and handed over to the civil power, with the request that he should be treated gently and "without the shedding of blood." This meant that he was to be burnt; and burnt accordingly he was, on Feb. 16, 1600. To escape a similar fate, Galileo, thirty-three years afterwards, abjured, upon his knees and with his hand on the holy gospels, the heliocentric doctrine. After Galileo came Kepler, who from his German home defied the power beyond the Alps. He traced out from pre-existing observations the laws of planetary motion. The problem was thus prepared for Newton, who bound those empirical laws together by the principle of gravitation.

During the Middle Ages the doctrine of atoms had to all appearance vanished from discussion. In all probability it held its ground among sober-minded and thoughtful men, though neither the Church nor the world was prepared to hear of it with tolerance. Once, in the year 1348, it received distinct expression. But retractation by compulsion immediately followed, and thus discouraged, it slumbered till the 17th century, when it was revived by a contemporary of Hobbes and Descartes, the Père Gassendi.

The analytic and synthetic tendencies of the human mind exhibit themselves throughout history, great writers ranging themselves sometimes on the one side, sometimes on the other. Men of lofty feelings, and minds open to the elevating impressions produced by nature as a whole, whose satisfaction, therefore, is rather ethical than logical, have leaned to the synthetic side; while the analytic harmonizes best with the more precise and more mechanical bias which seeks the satisfaction of the understanding. Some form of pantheism was usually adopted by the one, while a detached Creator, working more or less after the manner of men, was often assumed by the other.* Gassendi is hardly to be

* Boyle's model of the universe was the Strasburg clock with an outside artificer. Goethe, on the other hand, sang

ranked with either. Having formally acknowledged God as the first great cause, he immediately drops the idea, applies the known laws of mechanics to the atoms, and thence deduces all vital phenomena. God who created earth and water, plants and animals, produced in the first place a definite number of atoms, which constituted the seed of all things. Then began that series of combinations and decompositions which goes on at the present day, and which will continue in the future. The principle of every change resides in matter. In artificial productions the moving principle is different from the material worked upon; but in nature the agent works within, being the most active and mobile part of the material itself. Thus this bold ecclesiastic, without incurring the censure of the Church or the world, contrives to outstrip Mr. Darwin. The same cast of mind which caused him to detach the Creator from his universe led him also to detach the soul from the body, though to the body he ascribes an influence so large as to render the soul almost unnecessary. The aberrations of reason were in his view an affair of the material brain. Mental disease is brain-disease; but then the immortal reason sits apart, and cannot be touched by the disease. The errors of madness are errors of the instrument, not of the performer.

It may be more than a mere result of education, connecting itself probably with the deeper mental structure of the two men, that the idea of Gassendi, above enunciated, is substantially the same as that expressed by Prof. Clerk Maxwell at the close of the very noble lecture delivered by him at Bradford last year. According to both philosophers, the atoms, if I understand aright, are the *prepared materials*, the "manufactured articles," which, formed by the skill of the Highest, produce by their subsequent interaction all the phenomena of the material world. There seems to be this difference, however, between Gassendi and Maxwell. The one *postulates*, the other *infers* his first cause. In his manufactured articles, Prof. Maxwell finds the basis of an induction which enables him to scale philosophical heights considered inaccessible by Kant, and to take the logical step from the atoms to their Maker.

The atomic doctrine, in whole or in part, was entertained by Bacon, Descartes, Hobbes, Locke, Newton, Boyle, and their successors, until the chemical law of multiple proportions enabled Dalton to confer upon it an entirely new significance. In our day there are secessions from the theory, but it still stands firm. Only a year or two ago Sir William Thomson, with characteristic penetration, sought to determine the sizes of the atoms, or rather to fix the limits between which their sizes lie; while only last year the discourses of Williamson and Maxwell illustrate the present hold of the doctrine upon the foremost scientific minds. What these atoms, self-moved and self-posited, can and cannot accomplish in relation to life, is at the present moment the subject of profound scientific thought. I doubt the legitimacy of Maxwell's logic; but it is impossible not to feel the ethic glow with which his lecture concludes. There is, moreover, a Lucretian grandeur in his description of the steadfastness of the atoms:—"Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built, the foundation stones of the material universe, remain unbroken and unworn."

Ninety years subsequent to Gassendi the doctrine of bodily instruments, as it may be called, assumed immense importance in the hands of Bishop Butler, who, in his famous "Analogy of Religion," developed, from his own point of view, and with consummate sagacity, a similar idea. The bishop still influences superior minds; and it will repay us to dwell for a moment on his views. He draws the sharpest distinction between our real selves and our bodily instruments. He does not, as far as I remember, use the word soul, possibly because the term was so hackneyed in his day, as it had been for many generations previously. But he speaks of "living powers," "perceiving" or "percipient powers," "moving agents," "ourselves," in the same sense as we should employ the term soul. He dwells upon the fact that limbs may be removed and mortal diseases assail the body, while the mind, almost up to the moment of death, re-

"Ihm ziemt's die Welt im Innern zu bewegen,
Natur in sich, sich in Natur zu hegen."

The same repugnance to the clockmaker conception is manifest in Carlyle.

mains clear. He refers to sleep and to swoon, where the "living powers" are suspended but not destroyed. He considers it quite as easy to conceive of an existence out of our bodies as in them; that we may animate a succession of bodies, the dissolution of all of them having no more tendency to dissolve our real selves, or "deprive us of living faculties — the faculties of perception and action — than the dissolution of any foreign matter which we are capable of receiving impressions from, or making use of, for the common occasions of life." This is the key of the bishop's position. "Our organized bodies are no more a part of ourselves than any other matter around us." In proof of this he calls attention to the use of glasses, which "prepare objects" for the "percipient power" exactly as the eye does. The eye itself is no more percipient than the glass, and is quite as much the instrument of the true self, and also as foreign to the true self, as the glass is. "And if we see with our eyes only in the same manner as we do with glasses, the like may justly be concluded from analogy of all our senses."

Lucretius, as you are aware, reached a precisely opposite conclusion; and it certainly would be interesting, if not profitable, to us all, to hear what he would or could urge in opposition to the reasoning of the bishop. As a brief discussion of the point will enable us to see the bearings of an important question, I will here permit a disciple of Lucretius to try the strength of the bishop's position, and then allow the bishop to retaliate, with the view of rolling back, if he can, the difficulty upon Lucretius. Each shall state his case fully and frankly; and you shall be umpire between them. The argument might proceed in this fashion: —

"Subjected to the test of mental presentation (*Vorstellung*) your views, most honoured prelate, would present to many minds a great, if not an insuperable difficulty. You speak of 'living powers,' 'percipient or perceiving powers,' and 'ourselves;' but can you form a mental picture of any one of these apart from the organism through which it is supposed to act? Test yourself honestly, and see whether you possess any faculty that would enable you to form such a conception. The true self has a local habitation in each of us; thus localized, must it not possess a form? If so, what form? Have you ever for a moment realized it? When a leg is amputated the body is divided ino two parts; is the true self in both of them or in one? Thomas Aquinas might say in both; but not you, for you appeal to the consciousness associated with one of the two parts to prove that the other is foreign matter. Is consciousness, then, a necessary element of the true self? If so, what do you say to the case of the whole body being deprived of consciousness? If not, then on what grounds do you deny any portion of the true self to the severed limb? It seems very singular that, from the beginning to the end of your admirable book (and no one admires its sober strength more than I do), you never once mention the brain or nervous system. You begin at one end of the body, and show that its parts may be removed without prejudice to the perceiving power. What if you begin at the other end, and remove, instead of the leg, the brain? The body, as before, is divided into two parts; but both are now in the same predicament, and neither can be appealed to to prove that the other is foreign matter. Or, instead of going so far as to remove the brain itself, let a certain portion of its bony covering be removed, and let a rhythmic series of pressure and relaxations of pressure be applied to the soft substance. At every pressure 'the faculties of perception and of action' vanish; at every relaxation of pressure they are restored. Where, during the intervals of pressure, is the perceiving power? I once had the discharge of a Leyden battery passed unexpectedly through me: I felt nothing, but was simply blotted out of conscious existence for a sensible interval. Where was my true self during that interval? Men who have recovered from lightning-stroke have been much longer in the same state, and indeed in cases of ordinary concussion of the brain, days may elapse during which no experience is registered in consciousness. Where is the man himself during the period of insensibility? You may say that I beg the question when I assume the man to have been unconscious, that he was really conscious all the time, and has simply forgotten what had occurred to him. In reply to this, I can only say that no one need shrink from the worst tortures that superstition ever invented if only so felt and so remembered. I do not think your theory of instruments goes at all to the bottom of the matter. A telegraph operator has his intruments, by means of which he converses with

the world; our bodies possess a nervous system, which plays a similar part between the perceiving powers and external things. Cut the wires of the operator, break his battery, demagnetize his needle: by this means you certainly sever his connection with the world; but inasmuch as these are real instruments, their destruction does not touch the man who uses them. The operator survives, *and he knows that he survives.* What is it, I would ask, in the human system that answers to this conscious survival of the operator when the battery of the brain is so disturbed as to produce insensibility, or when it is destroyed altogether?

"Another consideration, which you may consider slight, presses upon me with some force. The brain may change from health to disease, and through such a change the most exemplary man may be converted into a debauchee or a murderer. My very noble and approved good master had, as you know, threatenings of lewdness introduced into his brain by his jealous wife's philter; and sooner than permit himself to run even the risk of yielding to these base promptings he slew himself. How could the hand of Lucretius have been thus turned against himself if the real Lucretius remained as before? Can the brain or can it not act in this distempered way without the intervention of the immortal reason? If it can, then it is a prime mover which requires only healthy regulation to render it reasonably self-acting, and there is no apparent need of your immortal reason at all. If it cannot, then the immortal reason, by its mischievous activity in operating upon a broken instrument, must have the credit of committing every imaginable extravagance and crime. I think, if you will allow me to say so, that the gravest consequences are likely to flow from your estimate of the body. To regard the brain as you would a staff or an eyeglass — to shut your eyes to all its mystery, to the perfect correlation that reigns between its condition and our consciousness, to the fact that a slight excess or defect of blood in it produces that very swoon to which you refer, and that in relation to it our meat and drink and air and exercise have a perfectly transcendental value and significance — to forget all this does, I think, open a way to innumerable errors in our habits of life, and may possibly in some cases initiate and foster that very disease, and consequent mental ruin, which a wiser appreciation of this mysterious organ would have avoided."

I can imagine the bishop thoughtful after hearing this argument. He was not the man to allow anger to mingle with the consideration of a point of this kind. After due consideration, and having strengthened himself by that honest contemplation of the facts which was habitual with him, and which includes the desire to give even adverse facts their due weight, I can suppose the bishop to proceed thus: — "You will remember that in the 'Analogy of Religion,' of which you have so kindly spoken, I did not profess to prove anything absolutely, and that I over and over again acknowledged and insisted on the smallness of our knowledge, or rather the depth of our ignorance, as regards the whole system of the universe. My object was to show my deistical friends who set forth so eloquently the beauty and beneficence of Nature and the Ruler thereof, while they had nothing but scorn for the so-called absurdities of the Christian scheme, that they were in no better condition than we were, and that for every difficulty they found upon our side, quite as great a difficulty was to be found on theirs. I will now with your permission adopt a similar line of argument. You are a Lucretian, and from the combination and separation of atoms deduce all terrestrial things, including organic forms and their phenomena. Let me tell you in the first instance how far I am prepared to go with you. I admit that you can build crystalline forms out of this play of molecular force; that the diamond, amethyst, and snow-star are truly wonderful structures which are thus produced. I will go further and acknowledge that even a tree or flower might in this way be organized. Nay, if you can show me an animal without sensation, I will concede to you that it also might be put together by the suitable play of molecular force.

"Thus far our way is clear, but now comes my difficulty. Your atoms are individually without sensation, much more are they without intelligence. May I ask you, then, to try your hand upon this problem. Take your dead hydrogen atoms, your dead oxygen atoms, your dead carbon atoms, your dead nitrogen atoms, your dead phosphorus atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless;

observe them running together and forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion are to arise? You speak of the difficulty of mental presentation in my case; is it less in yours? I am not all bereft of this *Vorstellungs-kraft* of which you speak. I can follow a particle of musk until it reaches the olfactory nerve; I can follow the waves of sound until their tremors reach the water of the labyrinth, and set the otoliths and Corti's fibres in motion; I can also visualize the waves of ether as they cross the eye and hit the retina. Nay, more, I am able to follow up to the central organ the motion thus imparted at the periphery, and to see in idea the very molecules of the brain thrown into tremors. My insight is not baffled by these physical processes. What baffles me, what I find unimaginable, transcending every faculty I possess — transcending, I humbly submit, every faculty *you* possess — is the notion that out of those physical tremors you can extract things so utterly incongruous with them as sensation, thought, and emotion. You may say, or think, that this issue of consciousness from the clash of atoms is not more incongruous than the flash of light from the union of oxygen and hydrogen. But I beg to say that it is. For such incongruity as the flash possesses is that which I now force upon your attention. The flash is an affair of consciousness, the objective counterpart of which is a vibration. It is a flash only by our interpretation. *You* are the cause of the apparent incongruity; and *you* are the thing that puzzles me. I need not remind you that the great Leibnitz felt the difficulty which I feel, and that to get rid of this monstrous deduction of life from death he displaced your atoms by his monads, and which were more or less perfect mirrors of the universe, and out of the summation and integration of which he supposed all the phenomena of life — sentient, intellectual, and emotional — to arise.

"Your difficulty, then, as I see you are ready to admit, is quite as great as mine. You cannot satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which materialism must inevitably split whenever it pretends to be a complete philosophy of life. What is the moral, my Lucretian? You and I are not likely to indulge in ill-temper in the discussion of these great topics, where we see so much room for honest differences of opinion. But there are people of less wit, or more bigotry (I say it with humility) on both sides, who are ever ready to mingle anger and vituperation with such discussions. There are, for example, writers of note and influence at the present day who are not ashamed to assume the 'deep personal sin' of a great logician to be the cause of his unbelief in a theologic dogma. And there are others who hold that we, who cherish our noble Bible, wrought as it has been into the constitution of our forefathers, and by inheritance into us, must necessarily be hypocritical and insincere. Let us disavow and discountenance such people, cherishing the unwavering faith that what is good and true in both our arguments will be preserved for the benefit of humanity, while all that is bad or false will disappear."

It is worth remarking that in one respect the bishop was a product of his age. Long previous to his day the nature of the soul had been so favourite and general a topic of discussion, that when the students of the University of Paris wished to know the leanings of a new professor, they at once requested him to lecture upon the soul. About the time of Bishop Butler the question was not only agitated but extended. It was seen by the clear-witted men who entered this arena that many of their best arguments applied equally to brutes and men. The bishop's arguments were of this character. He saw it, admitted it, accepted the consequences, and boldly embraced the whole animal world in his scheme of immortality.

Bishop Butler accepted with unwavering trust the chronology of the Old Testament, describing it as "confirmed by the natural and civil history of the world, collected from common historians, from the state of the earth, and from the late inventions of arts and sciences." These words mark progress: they must seem somewhat hoary to the bishop's successors of to-day.* It is hardly necessary to inform you that since his time the domain of the naturalist has been immensely extended — the whole science of geol-

* Only to some; for there are dignitaries who even now speak of the earth's rocky crust as so much building material prepared for man at the Creation. Surely it is time that this loose language should cease.

ogy, with its astounding revelations regarding the life of the ancient earth, having been created. The rigidity of old conceptions has been relaxed, the public mind being rendered gradually tolerant of the idea that not for six thousand, nor for sixty thousand, nor for six thousand thousand, but for æons embracing untold millions of years, this earth has been the theatre of life and death. The riddle of the rocks has been read by the geologist and palæontologist, from sub-cambrian depths to the deposits thickening over the sea-bottoms of to-day. And upon the leaves of that stone book are, as you know, stamped the characters, plainer and surer than those formed by the ink of history, which carry the mind back into abysses of past time compared with which the periods which satisfied Bishop Butler cease to have a visual angle. Everybody now knows this; all men admit it; still, when they were first broached these verities of science found loud-tongued denunciators, who proclaimed not only their baselessness considered scientifically, but their immorality considered as questions of ethics and religion: the Book of Genesis had stated the question in a different fashion; and science must necessarily go to pieces when it clashed with this authority. And as the seed of the thistle produces a thistle, and nothing else, so these objectors scatter their germs abroad, and reproduce their kind, ready to play again the part of their intellectual progenitors, to show the same virulence, the same ignorance, to achieve for a time the same success, and finally to suffer the same inexorable defeat. Sure the time must come at last when human nature in its entirety, whose legitimate demands it is admitted science alone cannot satisfy, will find interpreters and expositors of a different stamp from those rash and ill-informed persons who have been hitherto so ready to hurl themselves against every new scientific revelation, lest it should endanger what they are pleased to consider theirs.

The lode of discovery once struck, those petrified forms in which life was at one time active, increased to multitudes and demanded classification. The general fact soon became evident that none but the simplest forms of life lie lowest down, that as we climb higher and higher among the superimposed strata more perfect forms appear. The change, however, from form to form was not continuous — but by steps, some small, some great. "A section," says Mr. Huxley, "a hundred feet thick will exhibit at different heights a dozen species of ammonite, none of which passes beyond its particular zone of limestone, or clay, into the zone below it, or into that above it." In the presence of such facts it was not possible to avoid the question, Have these forms, showing, though in broken stages and with many irregularities, this unmistakable general advance, been subjected to no continuous law of growth or variation? Had our education been purely scientific, or had it been sufficiently detached from influences which, however ennobling in another domain, have always proved hindrances and delusions when introduced as factors into the domain of physics, the scientific mind never could have swerved from the search for a law of growth, or allowed itself to accept the anthropomorphism which regarded each successive stratum as a kind of mechanic's bench for the manufacture of new species out of all relation to the old.

Biassed, however, by their previous education, the great majority of naturalists invoked a special creative act to account for the appearance of each new group of organisms. Doubtless there were numbers who were clear-headed enough to see that this was no explanation at all, that in point of fact it was an attempt, by the introduction of a greater difficulty, to account for a less. But having nothing to offer in the way of explanation, they for the most part held their peace. Still the thoughts of reflecting men naturally and necessarily simmered round the question. De Maillet, a contemporary of Newton, has been brought into notice by Prof. Huxley as one who "had a notion of the modifiability of living forms." In my frequent conversations with him, the late Sir Benjamin Brodie, a man of high philosophic mind, often drew my attention to the fact that, as early as 1794, Charles Darwin's grandfather was the pioneer of Charles Darwin. In 1801, and in subsequent years, the celebrated Lamarck, who produced so profound an impression on the public mind through the vigorous exposition of his views by the author of "Vestiges of Creation," endeavoured to show the development of species out of changes of habit and external condition. In 1813, Dr. Wells, the founder of our present theory of dew, read before the Royal Society a paper in which, to use the words of Mr. Darwin, "he distinctly recognizes the principle of natural selection; and this is the first

recognition that has been indicated." The thoroughness and skill with which Wells pursued his work, and the obvious independence of his character, rendered him long ago a favourite with me; and it gave me the liveliest pleasure to alight upon this additional testimony to his penetration. Prof. Grant, Mr. Patrick Matthew, Von Buch, the author of the "Vestiges," D'Halloy, and others,* by the enunciation of views more or less clear and correct, showed that the question had been fermenting long prior to the year 1858, when Mr. Darwin and Mr. Wallace simultaneously but independently placed their closely concurrent views upon the subject before the Linnæan Society.

These papers were followed in 1859 by the publication of the first edition of "The Origin of Species." All great things come slowly to the birth. Copernicus, as I informed you, pondered his great work for thirty-three years. Newton for nearly twenty years kept the idea of Gravitation before his mind; for twenty years also he dwelt upon his discovery of Fluxions, and doubtless would have continued to make it the object of his private thought had he not found that Leibnitz was upon his track. Darwin for two-and-twenty years pondered the problem of the origin of species, and doubtless he would have continued to do so had he not found Wallace upon his track.† A concentrated but full and powerful epitome of his labours was the consequence. The book was by no means an easy one; and probably not one in every score of those who then attacked it had read its pages through, or were competent to grasp their significance if they had. I do not say this merely to discredit them; for there were in those days some really eminent scientific men, entirely raised above the heat of popular prejudice, willing to accept any conclusion that science had to offer, provided it was duly backed by fact and argument, and who entirely mistook Mr. Darwin's views. In fact the work needed an expounder; and it found one in Mr. Huxley. I know nothing more admirable in the way of scientific exposition than those early articles of his on the origin of species. He swept the curve of discussion through the really significant points of the subject, enriched his exposition with profound original remarks and reflections, often summing up in a single pithy sentence an argument which a less compact mind would have spread over pages. But there is one impression made by the book itself which no exposition of it, however luminous, can convey; and that is the impression of the vast amount of labour, both of observation and of thought, implied in its production. Let us glance at its principles.

It is conceded on all hands that what are called varieties are continually produced. The rule is probably without exception. No chick and no child is in all respects and particulars the counterpart of its brother or sister; and in such differences we have "variety" incipient. No naturalist could tell how far this variation could be carried; but the great mass of them held that never by any amount of internal or external change, nor by the mixture of both, could the offspring of the same progenitor so far deviate from each other as to constitute different species. The function of the experimental philosopher is to combine the conditions of nature and to produce her results; and this was the method of Darwin.* He made himself acquainted with what could, without any matter of doubt, be done in the way of producing variation. He associated himself with pigeon-fanciers — bought, begged, kept, and observed every breed that he could obtain. Though derived from a common stock, the diversities of these pigeons were such that "a score of them might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species." The simple principle which guides the pigeon-fancier, as it does the cattle-breeder, is the selection of some variety that strikes his fancy, and the propagation of this variety by inheritance. With his eye still upon the particular appearance which he wishes to exaggerate, he selects it as it reappears in successive broods, and thus adds increment to increment until an astonishing amount of divergence from the parent type is effected. Man in this case does not produce the *elements* of the variation. He simply ob-

* In 1855 Mr. Herbert Spencer ("Principles of Psychology," 2nd edit. vol. i. p. 465) expressed "the belief that life under all its forms has arisen by an unbroken evolution, and through the instrumentality of what are called natural causes."

† The behaviour of Mr. Wallace in relation to this subject has been dignified in the highest degree.

* The first step only towards experimental demonstration has been taken. Experiments now begun might, a couple of centuries hence, furnish data of incalculable value, which ought to be supplied to the science of the future

serves them, and by selection adds them together until the required result has been obtained. "No man," says Mr. Darwin, "would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter until he saw a pigeon with a crop of unusual size." Thus nature gives the hint, man acts upon it, and by the law of inheritance exaggerates the deviation.

Having thus satisfied himself by indubitable facts that the organism of an animal or of a plant (for precisely the same treatment applies to plants) is to some extent plastic, he passes from variation under domestication to variation under nature. Hitherto we have dealt with the adding together of small changes by the conscious selection of man. Can Nature thus select? Mr. Darwin's answer is, "Assuredly she can." The number of living things produced is far in excess of the number that can be supported; hence at some period or other of their lives there must be a struggle for existence; and what is the infallible result? If one organism were a perfect copy of the other in regard to strength, skill, and agility, external conditions would decide. But this is not the case. Here we have the fact of variety offering itself to nature, as in the former instance it offered itself to man; and those varieties which are least competent to cope with surrounding conditions will infallibly give way to those that are competent. To use a familiar proverb, the weakest comes to the wall. But the triumphant fraction again breeds to over-production, transmitting the qualities which secured its maintenance, but transmitting them in different degrees. The struggle for food again supervenes, and those to whom the favourable quality has been transmitted in excess will assuredly triumph. It is easy to see that we have here the addition of increments favourable to the individual still more rigorously carried out than in the case of domestication; for not only are unfavourable specimens not selected by nature, but they are destroyed. This is what Mr. Darwin calls "natural selection," which "acts by the preservation and accumulation of small inherited modifications, each profitable to the preserved being." With this idea he interpenetrates and leavens the vast store of facts that he and others have collected. We cannot, without shutting our eyes through fear or prejudice, fail to see that Darwin is here dealing, not with imaginary, but with true causes; nor can we fail to discern what vast modifications may be produced by natural selection in periods sufficiently long. Each individual increment may resemble what mathematicians call a "differential" (a quantity indefinitely small); but definite and great changes may obviously be produced by the integration of these infinitesimal quantities through practically infinite time.

If Darwin, like Bruno, rejects the notion of creative power acting after human fashion, it certainly is not because he is unacquainted with the numberless exquisite adaptations in which this notion of a supernatural artificer has founded. His book is a repository of the most startling facts of this description. Take the marvellous observation which he cites from Dr. Crüger, where a bucket with an aperture, serving as a spout, is formed in an orchid. Bees visit the flower: in eager search of material for their combs, they push each other into the bucket, the drenched ones escaping from their involuntary bath by the spout. Here they rub their backs against the viscid stigma of the flower and obtain glue; then against the pollen-masses, which are thus stuck to the back of the bee and carried away. "When the bee, thus provided, flies to another flower, or to the same flower a second time, and is pushed by its comrades into the bucket, and then crawls out by the passage, the pollen-mass upon its back necessarily comes first into contact with the viscid stigma," which takes up the pollen; and this is how that orchid is fertilized. Or take this other case of the *Catasetum*. "Bees visit these flowers in order to gnaw the labellum; on doing this they inevitably touch a long, tapering, sensitive projection. This, when touched, transmits a sensation or vibration to a certain membrane, which is instantly ruptured, setting free a spring, by which the pollen-mass is shot forth like an arrow in the right direction, and adheres by its viscid extremity to the back of the bee." In this way the fertilizing pollen is spread abroad.

It is the mind thus stored with the choicest materials of the teleologist that rejects teleology, seeking to refer these wonders to natural causes. They illustrate, according to him, the method of nature, not the "technic" of a man-like artificer. The beauty of flowers is due to natural selection. Those that distinguish themselves by vividly contrasting

colours from the surrounding green leaves are most readily seen, most frequently visited by insects, most often fertilized, and hence most favoured by natural selection. Coloured berries also readily attract the attention of birds and beasts, which feed upon them, spread their manured seeds abroad, thus giving trees and shrubs possessing such berries a greater chance in the struggle for existence.

With profound analytic and synthetic skill, Mr. Darwin investigates the cell-making instinct of the hive-bee. His method of dealing with it is representative. He falls back from the more perfectly to the less perfectly developed instinct — from the hive-bee to the humble-bee, which uses its own cocoon as a comb, and to classes of bees of intermediate skill, endeavouring to show how the passage might be gradually made from the lowest to the highest. The saving of wax is the most important point in the economy of bees. Twelve to fifteen pounds of dry sugar are said to be needed for the secretion of a single pound of wax. The quantities of nectar necessary for the wax must therefore be vast; and every improvement of constructive instinct which results in the saving of wax is a direct profit to the insect's life. The time that would otherwise be devoted to the making of wax is now devoted to the gathering and storing of honey for winter food. He passes from the humble-bee with its rude cells, through the Melipona with its more artistic cells, to the hive-bee with its astonishing architecture. The bees place themselves at equal distances apart upon the wax, sweep and excavate equal spheres round the selected points. The spheres intersect, and the planes of intersection are built up with thin laminæ. Hexagonal cells are thus formed. This mode of treating such questions is, as I have said, representative. He habitually retires from the more perfect and complex, to the less perfect and simple, and carries you with him through stages of *perfecting*, adds increment to increment of infinitesimal change, and in this way gradually breaks down your reluctance to admit that the exquisite climax of the whole could be a result of natural selection.

Mr. Darwin shirks no difficulty; and, saturated as the subject was with his own thought, he must have known, better than his critics, the weakness as well as the strength of his theory. This of course would be of little avail were his object a temporary dialectic victory instead of the establishment of a truth which he means to be everlasting. But he takes no pains to disguise the weakness he has discerned; nay, he takes every pains to bring it into the strongest light. His vast resources enable him to cope with objections started by himself and others, so as to leave the final impression upon the reader's mind that if they be not completely answered they certainly are not fatal. Their negative force being thus destroyed, you are free to be influenced by the vast positive mass of evidence he is able to bring before you. This largeness of knowledge and readiness of resource render Mr. Darwin the most terrible of antagonists. Accomplished naturalists have levelled heavy and sustained criticisms against him — not always with the view of fairly weighing his theory, but with the express intention of exposing its weak points only. This does not irritate him. He treats every objection with a soberness and thoroughness which even Bishop Butler might be proud to imitate, surrounding each fact with its appropriate detail, placing it in its proper relations, and usually giving it a significance which, as long as it was kept isolated, failed to appear. This is done without a trace of ill-temper. He moves over the subject with the passionless strength of a glacier; and the grinding of the rocks is not always without a counterpart in the logical pulverization of the objector. But though in handling this mighty theme all passion has been stilled, there is an emotion of the intellect incident to the discernment of new truth which often colours and warms the pages of Mr. Darwin. His success has been great; and this implies not only the solidity of his work, but the preparedness of the public mind for such a revelation. On this head a remark of Agassiz impressed me more than anything else. Sprung from a race of theologians, this celebrated man combated to the last the theory of natural selection. One of the many times I had the pleasure of meeting him in the United States was at Mr. Winthrop's beautiful residence at Brookline, near Boston. Rising from luncheon, we all halted as if by a common impulse in front of a window, and continued there a discussion which had been started at table. The maple was in its autumn glory; and the exquisite beauty of the scene outside seemed, in my case, to interpenetrate

without disturbance the intellectual action. Earnestly, almost sadly, Agassiz turned and said to the gentlemen standing round, "I confess that I was not prepared to see this theory received as it has been by the best intellects of our time. Its success is greater than I could have thought possible.".

In our day great generalizations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more radical significance, is the doctrine of the Conservation of Energy, the ultimate philosophical issues of which are as yet but dimly seen — that doctrine which "binds nature fast in fate" to an extent not hitherto recognized, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connection which, as far as the human understanding has yet pierced, asserts itself everywhere in nature. Long in advance of all definite experiment upon the subject, the constancy and indestructibility of matter had been affirmed; and all subsequent experience justified the affirmation. Later researches extended the attribute of indestructibility to force. This idea, applied in the first instance to inorganic, rapidly embraced organic nature. The vegetable world, though drawing almost all its nutriment from invisible sources, was proved incompetent to generate anew either matter or force. Its matter is for the most part transmuted air; its force transformed solar force. The animal world was proved to be equally uncreative, all its motive energies being referred to the combustion of its food. The activity of each animal as a whole was proved to be the transferred activities of its molecules. The muscles were shown to be stores of mechanical force, potential until unlocked by the nerves, and then resulting in muscular contractions. The speed at which messages fly to and fro along the nerves was determined, and found to be, not as had been previously supposed, equal to that of light or electricity, but less than the speed of a flying eagle.

This was the work of the physicist: then came the conquests of the comparative anatomist and physiologist, revealing the structure of every animal, and the function of every organ in the whole biological series, from the lowest zoophyte up to man. The nervous system had been made the object of profound and continued study, the wonderful and, at bottom, entirely mysterious controlling power which it exercises over the whole organism, physical and mental, being recognized more and more. Thought could not be kept back from a subject so profoundly suggestive. Besides the physical life dealt with by Mr. Darwin, there is a psychical life presenting similar gradations, and asking equally for a solution. How are the different grades and orders of mind to be accounted for? What is the principle of growth of that mysterious power which on our planet culminates in Reason? These are questions which, though not thrusting themselves so forcibly upon the attention of the general public, had not only occupied many reflecting minds, but had been formally broached by one of them before the "Origin of Species" appeared.

With the mass of materials furnished by the physicist and physiologist in his hands, Mr. Herbert Spencer, twenty years ago, sought to graft upon this basis a system of psychology; and two years ago a second and greatly amplified edition of his work appeared. Those who have occupied themselves with the beautiful experiments of Plateau, will remember that when two spherules of olive-oil suspended in a mixture of alcohol and water of the same density as the oil are brought together, they do not immediately unite. Something like a pellicle appears to be formed around the drops, the rupture of which is immediately followed by the coalescence of the globules into one. There are organisms whose vital actions are almost as purely physical as that of these drops of oil. They come into contact and fuse themselves thus together. From such organisms to others a shade higher, and from these to others a shade higher still, and on through an ever-ascending series, Mr. Spencer conducts his argument. There are two obvious factors to be here taken into account — the creature and the medium in which it lives, or, as it is often expressed, the organism and its environment. Mr. Spencer's fundamental principle is, that between these two factors there is incessant interaction. The organism is played upon by the environment, and is modified to meet the requirements of the environment. Life he defines to be "a continuous adjustment of internal relations to external relations."

In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions

from without and their corresponding adjustment, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognized 2,300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees the action becomes localized in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is here incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed as the interception of the light is in almost all cases by the contact of the closely adjacent opaque body, sight in this condition becomes a kind of "anticipatory touch." The adjustment continues; a slight bulging out of the epidermis over the pigment-granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and the eagle. So of the other senses; they are special differentiations of a tissue which was originally vaguely sensitive all over.

With the development of the senses the adjustments between the organism and its environment gradually extend in *space*, a multiplication of experiences and a corresponding modification of conduct being the result. The adjustments also extend in *time*, covering continually greater intervals. Along with this extension in space and time, the adjustments also increase in speciality and complexity, passing through the various grades of brute life and prolonging themselves into the domain of reason. Very striking are Mr. Spencer's remarks regarding the influence of the sense of touch upon the development of intelligence. This is, so to say, the mother-tongue of all the senses, into which they must be translated to be of service to the organism. Hence its importance. The parrot is the most intelligent of birds, and its tactual power is also greatest. From this sense it gets knowledge unattainable by birds which cannot employ their feet as hands. The elephant is the most sagacious of quadrupeds — its tactual range and skill, and the consequent multiplication of experiences, which it owes to its wonderfully adaptable trunk, being the basis of its sagacity. Feline animals, for a similar cause, are more sagacious than hoofed animals — atonement being to some extent made, in the case of the horse, by the possession of sensitive prehensile lips. In the *Primates* the evolution of intellect and the evolution of tactual appendages go hand in hand. In the most intelligent anthropoid apes we find the tactual range and delicacy greatly augmented, new avenues of knowledge being thus opened to the animal. Man crowns the edifice here, not only in virtue of his own manipulatory power, but through the enormous extension of his range of experience, by the invention of instruments of precision, which serve as supplemental senses and supplemental limbs. The reciprocal action of these is finely described and illustrated. That chastened intellectual emotion to which I have referred in connection with Mr. Darwin is, I should say, not absent in Mr. Spencer. His illustrations possess at times exceeding vividness and force, and from his style on such occasions it is to be inferred that the ganglia of this apostle of the understanding are sometimes the seat of a nascent poetic thrill.

It is a fact of supreme importance that actions, the performance of which at first requires even painful effort and deliberation, may by habit be rendered automatic. Witness the slow learning of its letters by a child, and the subsequent facility of reading in a man, when each group of letters which forms a word is instantly and without effort fused to a single perception. Instance the billiard-player, whose muscles of hand and eye, when he reaches the perfection of his art, are unconsciously co-ordinated. Instance the musician, who by practice is enabled to fuse a multitude of arrangements, auditory, tactual, and muscular, into a process of automatic manipulation. Combining such facts with the doctrine of hereditary transmission, we reach a theory of instinct. A chick, after coming out of the egg, balances itself correctly, runs about, picks up food, thus showing that it possesses a power of directing its movements to definite ends. How did the chick learn this very complex co-ordination of eye, muscles, and beak? It has not been individually taught; its personal experience is *nil*; but it has the benefit of ancestral experience. In its inherited organization are registered all the powers which it displays at birth. So also as regards the instinct of the hive-bee, already referred to. The distance

at which the insects stand apart when they sweep their hemispheres and build their cells is "organically remembered." Man also carries with him the physical texture of his ancestry, as well as the inherited intellect bound up with it. The defects of intelligence during infancy and youth are probably less due to a lack of individual experience than to the fact that in early life the cerebral organization is still incomplete. The period necessary for completion varies with the race and with the individual. As a round shot outstrips a rifled one on quitting the muzzle of the gun, so the lower race in childhood may outstrip the higher. But the higher eventually overtakes the lower, and surpasses it in range. As regards individuals, we do not always find the precocity of youth prolonged to mental power in maturity, while the dulness of boyhood is sometimes strikingly contrasted with the intellectual energy of after years. Newton, when a boy, was weakly, and he showed no particular aptitude at school; but in his eighteenth year he went to Cambridge, and soon afterwards astonished his teachers by his power of dealing with geometrical problems. During his quiet youth his brain was slowly preparing itself to be the organ of those energies which he subsequently displayed.

By myriad blows (to use a Lucretian phrase) the image and superscription of the external world are stamped as states of consciousness upon the organism, the depth of the impression depending upon the number of the blows. When two or more phenomena occur in the environment invariably together, they are stamped to the same depth or to the same relief, and are indissolubly connected. And here we come to the threshold of a great question. Seeing that he could in no way rid himself of the consciousness of space and time, Kant assumed them to be necessary "forms of thought," the moulds and shapes into which our intuitions are thrown, belonging to ourselves solely and without objective existence. With unexpected power and success Mr. Spencer brings the hereditary experience-theory, as he holds it, to bear upon this question. "If there exist certain external relations which are experienced by all organisms at all instants of their waking lives — relations which are absolutely constant and universal — there will be established answering internal relations that are absolutely constant and universal. Such relations we have in those of space and time. As the substratum of all other relations of the Non-Ego, they must be responded to by conceptions that are the substrata of all other relations in the Ego. Being the constant and infinitely repeated elements of thought, they must become the automatic elements of thought — the elements of thought which it is impossible to get rid of — the 'forms of intuition.'"

Throughout this application and extension of the "law of inseparable association," Mr. Spencer stands on totally different ground from Mr. John Stuart Mill, invoking the registered experiences of the race instead of the experiences of the individual. His overthrow of Mr. Mill's restriction of experience is, I think, complete. That restriction ignores the power of organizing experience furnished at the outset to each individual; it ignores the different degrees of this power possessed by different races and by different individuals of the same race. Were there not in the human brain a potency antecedent to all experience, a dog or cat ought to be as capable of education as a man. These predetermined internal relations are independent of the experiences of the individual. The human brain is the "organized register of infinitely numerous experiences received during the evolution of life, or rather during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest, and have slowly mounted to that high intelligence which lies latent in the brain of the infant. Thus it happens that the European inherits from twenty to thirty cubic inches more of brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakespeares."

At the outset of this address it was stated that physical theories which lie beyond experience are derived by a process of abstraction from experience. It is instructive to note from this point of view the successive introduction of new conceptions. The idea of the attraction of gravitation was preceded by the observation of the attraction of iron by a magnet, and of light bodies by rubbed amber.

The polarity of magnetism and electricity appealed to the senses; and thus became the substratum of the conception that atoms and molecules are endowed with definite, attractive, and repellent poles, by the play of which definite forms of crystalline architecture are produced. Thus molecular force becomes *structural*. It required no great boldness of thought to extend its play into organic nature, and to recognize in molecular force the agency by which both plants and animals are built up. In this way out of experience arise conceptions which are wholly ultra-experiential.

The *origination* of life is a point lightly touched upon, if at all, by Mr. Darwin and Mr. Spencer. Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one "primordial form;" but he does not say, as far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had "gradually learnt to see that it is just as noble a conception of the Deity to believe He created a few original forms, capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws." What Mr. Darwin thinks of this view of the introduction of life I do not know. Whether he does or does not introduce his "primordial form" by a creative act, I do not know. But the question will inevitably be asked, "How came the form there?" With regard to the diminution of the number of created forms, one does not see that much advantage is gained by it. The anthropomorphism, which it seemed the object of Mr. Darwin to set aside, is as firmly associated with the creation of a few forms as with the creation of a multitude. We need clearness and thoroughness here. Two courses, and two only, are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter. If we look at matter as pictured by Democritus, and as defined for generations in our scientific text-books, the absolute impossibility of any form of life coming out of it would be sufficient to render any other hypothesis preferable; but the definitions of matter gives in our text-books were intended to cover its purely physical and mechanical properties. And taught as we have been to regard these definitions as complete, we naturally and rightly reject the monstrous notion that out of *such* matter any form of life could possibly arise. But are the definitions complete? Everything depends on the answer to be given to this question. Trace the line of life backwards, and see it approaching more and more to what we call the purely physical condition. We reach at length those organisms which I have compared to drops of oil suspended in a mixture of alcohol and water. We reach the *protogenes* of Haeckel, in which we have a "type distinguishable from a fragment of albumen only by its finely granular character." Can we pause here? We break a magnet and find two poles in each of its fragments. We continue the process of breaking, but however small the parts, each carries with it, though enfeebled, the polarity of the whole. And when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that "Nature is seen to do all things spontaneously of herself without the meddling of the gods?" or with Bruno, when he declares that matter is not "that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb?" The questions here raised are inevitable. They are approaching us with accelerated speed, and it is not a matter of indifference whether they are introduced with reverence or irreverence. Abandoning all disguise, the confession that I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern in that matter, which we in our ignorance and notwithstanding our professed reverence for its Creator have hitherto covered with opprobrium, the promise and potency of every form and quality of life.

The "materialism" here enunciated may be different from what you suppose, and I therefore crave your gracious patience to the end. "The question of an external world," says Mr. J. S. Mill, "is the great battle-ground of metaphysics." * Mr. Mill himself reduces external phenomena to "possibilities of sensation." Kant, as we have seen, made time and space "forms" of our own intuitions. Fichte, having first by the inexorable

* "Examination of Hamilton," p. 154.

logic of his understanding proved himself to be a mere link in that chain of eternal causation which holds so rigidly in nature, violently broke the chain by making nature, and all that it inherits, an apparition of his own mind.* And it is by no means easy to combat such notions. For when I say I see you, and that I have not the least doubt about it, the reply is, that what I am really conscious of is an affection of my own retina. And if I urge that I can check my sight of you by touching you, the retort would be that I am equally transgressing the limits of fact; for what I am really conscious of is, not that you are there, but that the nerves of my hand have undergone a change. All we hear, and see, and touch, and taste, and smell, are, it would be urged, mere variations of our own condition, beyond which, even to the extent of a hair's breadth, we cannot go. That anything answering to our impressions exists outside of ourselves is not a *fact*, but an *inference*, to which all validity would be denied by an idealist like Berkeley, or by a sceptic like Hume. Mr. Spencer takes another line. With him, as with the uneducated man, there is no doubt or question as to the existence of an external world. But he differs from the uneducated, who think that the world really *is* what consciousness represents it to be. Our states of consciousness are mere *symbols* of an outside entity which produces them and determines the order of their succession, but the real nature of which we can never know.† In fact the whole process of evolution is the manifestation of a Power absolutely inscrutable to the intellect of man. As little in our day as in the days of Job can man by searching find this Power out. Considered fundamentally, it is by the operation of an insoluble mystery that life is evolved, species differentiated, and mind unfolded from their prepotent elements in the immeasurable past. There is, you will observe, no every rank materialism here.

The strength of the doctrine of evolution, consists, not in an experimental demonstration (for the subject is hardly accessible to this mode of proof), but in its general harmony with the method of nature as hitherto known. From contrast, moreover, it derives enormous relative strength. On the one side we have a theory (if it could with any propriety be so called) derived, as were the theories referred to at the beginning of this address, not from the study of nature, but from the observation of men — a theory which converts the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting by broken efforts as man is seen to act. On the other side we have the conception that all we see around us, and all we feel within us — the phenomena of physical nature as well as those of the human mind — have their unsearchable roots in a cosmical life, if I dare apply the term, an infinitesimal span of which only is offered to the investigation of man. And even this span is only knowable in part. We can trace the development of a nervous system, and correlate with it the parallel phenomena of sensation and thought. We see with undoubting certainty that they go hand in hand. But we try to soar in a vacuum the moment we seek to comprehend the connection between them. An Archimedean fulcrum is here required which the human mind cannot command; and the effort to solve the problem, to borrow an illustration from an illustrious friend of mine, is like the effort of a man trying to lift himself by his own waistband. All that has been here said is to be taken in connection with this fundamental truth. When "nascent senses" are spoken of, when "the differentiation of a tissue at first vaguely sensitive all over" is spoken of, and when these processes are associated with "the modification of an organism by its environment," the same parallelism, without contact, or even approach to contact, is implied. There is no fusion possible between the two classes of facts — no motor energy in the intellect of man to carry it without logical rupture from the one to the other.

Further, the doctrine of evolution derives man, in his totality, from the interaction of organism and environment

* "Bestimmung des Menschen."

† In a paper, at once popular and profound, entitled "Recent Progress in the Theory of Vision," contained in the volume of lectures by Helmholtz, published by Longmans, this symbolism of our states of consciousness is also dwelt upon. The impressions of sense are the mere *signs* of external things. In this paper Helmholtz contends strongly against the view that the consciousness of space is inborn; and he evidently doubts the power of the chick to pick up grains of corn without some preliminary lessons. On this point, he says, further experiments are needed. Such experiments have been since made by Mr. Spalding, aided, I believe, in some of his observations by the accomplished and deeply lamented Lady Amberley; and they seem to prove conclusively that the chick does not need a single moment's tuition to teach it to stand, run, govern the muscles of its eyes, and peck. Helmholtz, however, is contending against the notion of pre-established harmony; and I am not aware of his views as to the organization of experiences of race or breed.

through countless ages past. The human understanding, for example — the faculty which Mr. Spencer has turned so skilfully round upon its own antecedents — is itself a result of the play between organism and environment through cosmic ranges of time. Never surely did prescription plead so irresistible a claim. But then it comes to pass that, over and above his understanding, there are many other things appertaining to man whose prescriptive rights are quite as strong as that of the understanding itself. It is a result, for example, of the play of organism and environment that sugar is sweet and that aloes are bitter, that the smell of henbane differs from the perfume of a rose. Such facts of consciousness (for which, by the way, no adequate reason has ever yet been rendered) are quite as old as the understanding itself; and many other things can boast an equally ancient origin. Mr. Spencer at one place refers to that most powerful of passions — the amatory passion — as one which, when it first occurs, is antecedent to all relative experience whatever; and we may pass its claim as being at least as ancient and as valid as that of the understanding itself. Then there are such things woven into the texture of man as the feeling of awe, reverence, wonder — and not alone the sexual love just referred to, but the love of the beautiful, physical and moral, in nature, poetry, and art. There is also that deep-set feeling which, since the earliest dawn of history, and probably for ages prior to all history, incorporated itself in the religions of the world. You who have escaped from these religions in the high-and-dry light of the understanding may deride them; but in so doing you deride accidents of form merely, and fail to touch the immovable basis of the religious sentiment in the emotional nature of man. To yield this sentiment reasonable satisfaction is the problem of problems at the present hour. And grotesque in relation to scientific culture as many of the religions of the world have been and are — dangerous, nay, destructive, to the dearest privileges of freemen as some of them undoubtedly have been, and would, if they could, be again — it will be wise to recognize them as the forms of force, mischievous, if permitted to intrude on the region of *knowledge*, over which it holds no command, but capable of being guided by liberal thought to noble issues in the region of *emotion*, which is its proper sphere. It is vain to oppose this force with a view to its extirpation. What we should oppose, to the death if necessary, is every attempt to found upon this elemental bias of man's nature a system which should exercise despotic sway over his intellect. I do not fear any such consummation. Science has already to some extent leavened the world, and it will leaven it more and more. I should look upon the mild light of science breaking in upon the minds of the youth of Ireland, and strengthening gradually to the perfect day, as a surer check to any intellectual or spiritual tyranny which might threaten this island, than the laws of princes or the swords of emperors. Where is the cause of fear? We fought and won our battle even in the Middle Ages: why should we doubt the issue of a conflict now?

The impregnable position of science may be described in a few words. All religious theories, schemes, and systems, which embrace notions of cosmogony, or which otherwise reach into its domain, must, in so far as they do this, submit to the control of science, and relinquish all thought of controlling it. Acting otherwise proved disastrous in the past, and it is simply fatuous to-day. Every system which would escape the fate of an organism too rigid to adjust itself to its environment, must be plastic to the extent that the growth of knowledge demands. When this truth has been thoroughly taken in, rigidity will be relaxed, exclusiveness diminished, things now deemed essential will be dropped, and elements now rejected will be assimilated. The lifting of the life is the essential point; and as long as dogmatism, fanaticism, and intolerance are kept out, various modes of leverage may be employed to raise life to a higher level. Science itself not unfrequently derives motive power from an ultra-scientific source. Whewell speaks of enthusiasm of temper as a hindrance to science; but he means the enthusiasm of weak heads. There is a strong and resolute enthusiasm in which science finds an ally; and it is to the lowering of this fire, rather than to a diminution of intellectual insight, that the lessening productiveness of men of science in their maturer years is to be ascribed. Mr. Buckle sought to detach intellectual achievement from moral force. He gravely erred; for without moral force to whip it into action, the achievements of the intellect would be poor indeed.

It has been said that science divorces itself from literature. The statement,

like so many others, arises from lack of knowledge. A glance at the less technical writings of its leaders — of its Hehmholtz, its Huxley, and its Du Bois-Reymond — would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigour of literary style? Science desires no isolation, but freely combines with every effort towards the bettering of man's estate. Single-handed, and supported not by outward sympathy, but by inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands. And if rough walls and protruding rafter-ends indicate that on one side the edifice is still incomplete, it is only by wise combination of the parts required with those already irrevocably built that we can hope for completeness. There is no necessary incongruity between what has been accomplished and what remains to be done. The moral glow of Socrates, which we all feel by ignition, has in it nothing incompatible with the physics of Anaxagoras which he so much scorned, but which he would hardly scorn to-day. And here I am reminded of one amongst us, hoary, but still strong, whose prophet-voice, some thirty years ago, far more than any other of this age, unlocked whatever of life and nobleness lay latent in its most gifted minds — one fit to stand beside Socrates or the Maccabean Eleazar, and to dare and suffer all that they suffered and dared — fit, as he once said of Fichte, "to have been the teacher of the Stoa, and to have discoursed of beauty and virtue in the groves of Academe." With a capacity to grasp physical principles which his friend Goethe did not possess, and which even total lack of exercise has not been able to reduce to atrophy, it is the world's loss that he, in the vigour of his years, did not open his mind and sympathies to science, and make its conclusions a portion of his message to mankind. Marvellously endowed as he was — equally equipped on ths side of the heart and of the understanding — he might have done much towards teaching us how to reconcile the claims of both, and to enable them in coming times to dwell together in unity of spirit and in the bond of peace.

And now the end is come. With more time, or greater strength and knowledge, what has been here said might have been better said, while worthy matters here omitted might have received fit expression. But there would have been no material deviation from the views set forth. As regards myself, they are not the growth of a day; and as regards you, I thought you ought to know the environment which, with or without your consent, is rapidly surrounding you, and in relation to which some adjustment on your part may be necessary. A hint of Hamlet's, however, teaches us all how the troubles of common life may be ended; and it is perfectly possible for you and me to purchase intellectual peace at the price of intellectual death. The world is not without refuges of this description; nor is it wanting in persons who seek their shelter and try to persuade others to do the same. I would exhort you to refuse such shelter, and to scorn such base repose — to accept, if the choice be forced upon you, commotion before stagnation, the leap of the torrent before the stillness of the swamp. In the one there is at all events life, and therefore hope; in the other, none. I have touched on debatable questions, and led you over dangerous ground — and this partly with the view of telling you, and through you the world, that as regards these questions science claims unrestricted right of search. It is not to the point to say that the views of Lucretius and Bruno, of Darwin and Spencer, may be wrong. Here I should agree with you, deeming it indeed certain that these views will undergo modification. But the point is, that, whether right or wrong, we claim the freedom to discuss them. The ground which they cover is scientific ground; and the right claimed is one made good through tribulation and anguish, inflicted and endured in darker times than ours, but resulting in the immortal victories which science has won for the human race. I would set forth equally the inexorable advance of man's understanding in the path of knowledge, and the unquenchable claims of his emotional nature which the understanding can never satisfy. The world embraces not only a Newton, but a Shakespeare — not only a Boyle, but a Raphael — not only a Kant, but a Beethoven — not only a Darwin, but a Carlyle. Not in each of these, but in all, is human nature whole. They are not opposed, but supplementary — not mutually exclusive, but reconcilable. And if, still unsatisfied, the human mind, with the yearning of a pilgrim for his distant home, will turn to the mystery from which it has emerged, seeking so to fashion it as to give unity to

thought and faith, so long as this is done, not only without intolerance or bigotry of any kind, but with the enlightened recognition that ultimate fixity of conception is here unattainable, and that each succeeding age must be held free to fashion the mystery in accordance with its own needs — then, in opposition to all the restrictions of Materialism, I would affirm this to be a field for the noblest exercise of what, in contrast with the *knowing* faculties, may be called the *creative* faculties of man. Here, however, I must quit a theme too great for me to handle, but which will be handled by the loftiest minds ages after you and I, like streaks of morning cloud, shall have melted into the infinite azure of the past.

VOICES OF THE DEAD.

A FEW snow-patches on the mountain-side,
A few white foam-flakes from the ebbing tide,
A few remembered words of malice spent,
The record of some dead man's ill intent, —

They cannot hurt us, all their sting is gone,
Their hour of cold and bitterness is done;
Yet deepest snows and fiercest lashing seas
Bring not such cold or bitter thoughts as these.

A few soiled lilies dropped by childish hands,
A few dried orange-blooms from distant lands,
A few remembered smiles of some lost friend,
Few words of love some dear dead fingers penned, —

They are not beautiful for love to see,
And death's pale presence seems in them to be;
Yet never living blooms, most fresh and gay,
Fill us with thoughts of love so sweet as they.

Spectator. F. W. B.

END OF VOL. CXXII.